DOCUMENT RESUME

ED 052 962 SE 011 347

AUTHOR	Obradovic, Sylvia M.; And Others
TITLE	Implementing New Science Curricula and Course Content Improvement Materials.
INSTITUTION	Far West Lab. for Educational Research and Development, Berkeley, Calif.
SPONS AGENCY	National Science Foundation, Washington, D.C.
PUB DATE	Nov 70
NOTE	100p.
EDRS PRICE	EDRS Price MF-$0.65 HC-$3.29
DESCRIPTORS	*Adoption (Ideas), *Curriculum, Educational Research, Science Course Improvement Project, *Secondary School Science, Surveys

ABSTRACT

To identify factors affecting the implementation of new science curricula a questionnaire survey of principals and teachers in California and Nevada secondary schools was used to select a sample of schools using Chemical Education Materials Study (CHEM Study) or Introductory Physical Science (IPS). Interview data collected when these 67 schools were visited supplemented questionnaire data. The results indicated that effective implementation of new programs required the provision of assistance and support to school curriculum development personnel in terms of research and resource materials for curricular decision making, a total curriculum plan, appropriate inservice education, and continual curriculum evaluation and revision. A list of school procedures that help overcome specific problems, such as student deficiencies in mathematics or reading and inadequate teacher preparation time, is included. Tables summarize questionnaire data on teacher preparation, teachers' reports of implementation problems and their ranking of teacher needs for successful curriculum adoption. These tables are provided for IPS courses, biological sciences Curriculum Study (BSCS) Biology, CHEM Study, and Physical Science Study Committee (PSSC) Physics. Appendices provide copies of questionnaires and interview schedules used, and provide data on the school districts using the new curricula materials. (AL)

ED052962

IMPLEMENTING NEW SCIENCE CURRICULA AND COURSE CONTENT IMPROVEMENT MATERIALS

[illegible] NATIONAL [illegible]

FAR WEST LABORATORY FOR EDUCATIONAL RESEARCH AND DEVELOPMENT
1 Garden Circle, Hotel Claremont, Berkeley, California 94705

Produced by the FAR WEST LABORATORY FOR EDUCATIONAL RESEARCH AND DEVELOPMENT. The Laboratory was established through a Joint Powers Agreement in February 1966. Signatories as of June 1969 include:

The Regents of the University of California
The California State Board of Education
The Trustees of the California State Colleges
The County Superintendent of Schools of the County of Monterey
The Board of Education of the San Francisco Unified School District
The Regents of the University of Nevada
The Nevada State Board of Education
The Board of Regents of the University of Utah
The Utah State Board of Education

IMPLEMENTING NEW SCIENCE CURRICULA AND COURSE CONTENT IMPROVEMENT MATERIALS

by Sylvia M. Obradovic, Ph.D.

with the assistance of
Elizabeth Karplus and
Benjamin Yerger

November 1970

A Technical Report on a Project in
Science Education Funded by the
National Science Foundation under
Grant Award Number GW 2245

TABLE OF CONTENTS

LIST OF TABLES

OBJECTIVES AND METHODS OF THE STUDY

Outstanding new science curricula and course content improvement materials are constantly moving through the various stages of development and becoming available for use in the schools. There is often a significant lag between development of new materials and their wide adoption, even in the more innovative schools. This study was made to identify factors in the implementation process which are crucial in bringing about rapid and effective use of new educational materials.

Objectives

The primary objective of this project was to investigate those aspects of a selected new science curriculum that are related directly to its adoption and effective use in the schools. Secondary objectives of this project were:

1. To develop and maintain effective lines of communication among public school administrators, science teachers, persons involved in developing new science materials, consultants, and the project staff;
2. To determine the status of schools in California and Nevada regarding the use of new science curricula and course materials;
3. To bring about an increase in the adoption and successful use of new science curricula and materials in California and Nevada.

Methodology

The procedures utilized to achieve the stated objectives constitute the three phases of the project: a survey phase an evaluation phase, and a dissemination phase.

Survey Phase

The main purposes of this phase were to locate schools which were using or had used new science curricula and to identify their implementation problems and the specific kinds of help needed by teachers.

Questionnaires. Understandings gained through a study of literature reviews, classroom observations and conversations with science teachers and other school personnel and directors of science curriculum development projects led to the design of two questionnaires: one for school administrators and one for teachers.

The Principal's Questionnaire was designed to yield data on (a) the school's general characteristics, (b) the science program in particular, and (c) teacher inservice science education available in the area. The Teacher's Questionnaire was designed to yield data on (a) the teachers' preparation for teaching a specific new science curriculum, (b) the seriousness of specific problems (in areas of student preparation, suitability of curriculum, school plant and organization) and teachers' preparation or assistance needs, (c) the extent to which specific features of the curriculum were utilized or adapted, and (d) the teachers' perception of the effectiveness of the science curriculum. Open-ended questions on the questionnaires permitted the principals and teachers to express their opinions regarding critical problems in science curriculum development, and they further solicited from each teacher his personal evaluation of the curriculum he was teaching. The complete questionnaires are to be found in Appendices B and C to this report. A list of the new science curricula included in the questionnaire is repeated here.

List of New Science Curricula

Science Area	
General Science	ESCP--Earth Science Curriculum Project
	SSSP--Secondary School Science Project (Princeton Project) also known as Time, Space, and Matter
	IPS--Introductory Physical Science
	ESSP--Elementary School Science Project (Ill.)
	MSCC-JHSP--Michigan Science Curriculum Committee Junior High School Project
	SRA--Inquiry Approach also known as IDP--Inquiry Development Program
	IME--Interaction of Matter and Energy
Biology	Radioisotopes and Inquiry
	BSCS--Biological Science Curriculum Study Versions: Blue Version, Green Version, Yellow Version
	Patterns and Processes, also known as BSCS, Special Materials
	Interaction of Experiments and Ideas, also known as Advanced BSCS
Chemistry	CHEMS--Chemical Education Materials Study, also known as CHEM Study
	CBA--Chemical Bond Approach

Physics	PSSC--Physical Science Study Committee
	PSSC Advanced Topics--Physical Science Study Committee Advanced Topics Program
	HPP--Harvard Project Physics
	ECCP--Engineering Concepts Curriculum Project
	NSTS-NASA--Aerospace Science Education Project
	NASA--Aerospace Resource Guide
Other Science Courses	Portland Project (Integration of Chemistry and Physics)

Procedure. The study was launched after conducting a preliminary survey through county offices to locate school districts known to be using new science curricula and establishing contact with district superintendents of the schools. As a pilot test, the questionnaires were administered to 22 science teachers and principals in five schools in two counties.

The questionnaires were then revised, and the final forms were sent to virtually all schools teaching any secondary grades, seven through 12, in 59 California and Nevada counties. Principals and science teachers at schools offering any of the new science curricula shown on the preceding list were requested to complete and return the questionnaires within four school weeks.*

Three hundred-three principals and 890 teachers returned completed questionnaires. Returns from 307 schools using new

---

*These curricula are briefly described in Appendix A. Detailed descriptions of new curriculum projects are given in the Report of the International Clearing House on Science and Mathematics Curricular Developments, 1968, Science Teaching Center, University of Maryland, College Park, Maryland.

science curricula were usable. A follow-up by both letter and phone increased the usable returns to 950 completed Teacher's Questionnaires and 333 completed Principal's Questionnaires from 335 schools.

Data obtained was prepared for tabulating and submitted to electronic data processing. The resulting tables of data were appropriately examined, interpreted and summarized for each curriculum.

Sample. Through the cooperation of the county and district offices, responses were obtained from principals and teachers representing a widely divergent sample of schools. Questionnaire returns were obtained from 335 schools having student populations ranging from 17 to over 3,000. Of these schools, 56 had fewer than 500 students, 229 schools had between 400 and 2,000 students, and 43 schools had above 2,000 students.

Although the initial focus was on secondary school curricula, K-8 schools were included in order that the information obtained would be as complete as possible with regard to intermediate science programs. The distribution of the school sample for completed questionnaire returns according to school size and grade organization is given in Table 1.

Schools in the final sample included 129 in rural areas or small towns, 120 in suburbs and 59 in urban or large urban areas. The distribution of the sample according to the type of community and school grade organization is shown in detail in Table 2. The distribution by county of school districts using new science curricula is given in Appendices D, E and F.

Table 1

DISTRIBUTION OF SCHOOL SAMPLE BY SIZE AND GRADE ORGANIZATION

Elementary Junior High Schools: Grade Organization	Student Population Below 250	251-500	501-1200	1201-2000	Over 2000	Other	Total
K or 1 to 8	2	3	2				7
4, 5, or 6 to 7 or 8		4	7				11
7 to 8	3	11	15	1			30
7 to 9		2	23	7			32
Other						2	2
SUM	5	20	47	8		2	82
Senior High Schools: Grade Organization							
7 to 12	2	1	1	2			6
9 to 10						1	1
9 to 12	11	17	56	73	28	3	188
10 to 12			9	33	15		57
Other						1	1
SUM	13	18	66	108	43	5	253
TOTAL SAMPLE	18	38	113	116	43	7	335

Table 2

DISTRIBUTION OF SCHOOL SAMPLE BY TYPE OF COMMUNITY AND GRADE ORGANIZATION

Elementary and Junior High Schools: Grade Organization	Type of Community						
	Rural	Rural Town	Sub-Urban	Urban	Large Urban	Other	Total
K or 1 to 8	6	1					7
4, 5, or 6 to 7 or 8	2	3	6				11
7 to 8	1	5	17	3		4	30
7 to 9	1	11	5	11	2	2	32
Other	1					1	2
SUM	11	20	28	14	2	7	82
Senior High Schools: Grade Organization							
7 to 12	2	3	1				6
9 to 10			1				1
9 to 12	38	48	73	9	3	17	188
10 to 12	1	6	17	16	15	2	57
Other					1		1
SUM	41	57	92	25	18	20	253
TOTAL SAMPLE	52	77	120	39	20	27	335

Evaluation Phase

The major purpose of this phase was to investigate in-depth those aspects of specific new science curricula which are related directly to their adoption and effective use in the schools. In this way, the investigation constitutes an evaluation of the selected curricula with regard to these two aspects.

Selection of Curricula for In-depth Study. An examination of the responses on the questionnaires revealed that two alternative types of evaluative studies might be conducted: (a) a study of problems met upon introducing a new curriculum (i.e., transition state problems), or (b) a study of problems of maintaining an established curriculum (i.e., steady state problems). Some factors to consider with regard to each of these types of study are described here briefly.

When a new science curriculum is introduced into a school, personnel are confronted by short-term problems of articulation between this new curriculum and courses which come before and after it in the science sequence. Additional effort and time may be required for organizing the laboratory for the new course, especially in intermediate schools where the new curriculum may be the first one requiring laboratory facilities. Often special background information relative to the specific curriculum is a teaching prerequisite. Student, teacher, principal or parent attitudes may be biased with regard to the new program. These factors give rise to a set of problems which require approaches applicable to the transition state.

Where a curiculum is well established, experienced teachers may have experimented with modifications and adapted them to local school conditions. Adjustments made in an attempt to resolve articulation problems are more likely to have been made in the more established curricula than in the ones being newly introduced. Science teachers generally might be somewhat familiar with the innovative course even if they have not taught it and attitudes of students, school personnel and parents about the innovation will have probably stabilized. Thus, the set of problems arising under steady state conditions differs from the set arising in a transition state and requires different approaches to solution. In order to maximize the validity of this study, careful consideration was given to these factors in selecting the focus for intensive evaluative study.

The field of curricula, from which a selection could be made for the in-depth study, was narrowed to include only those for which there were sufficient schools for the study. Included were Physical Science Study Committee physics (PSSC physics), Chemical Education Materials Study (CHEM Study), Introductory Physical Science (IPS), Earth Science Curriculum Project (ESCP), and the four Biological Science Curriculum Study programs (BSCS biology). Of these IPS, ESCP and BSCS Special Materials are relatively new. IPS and ESCP are the only ones of this field which are taught in intermediate or junior high schools, and PSSC physics is offered primarily to male seniors taking a second year of algebra. Consequently, the sample of PSSC physics students would hardly be comparable to that of the other curricula. It was decided that the value of the study would be increased by focusing on one of the newer curricula taught at intermediate school levels, in addition, to one of the more established curricula taught in senior high schools. The evaluation, therefore, was concerned with both IPS and CHEM Study.

Design of Evaluation Instruments. In order to evaluate implementation it was desirable to focus upon components of teacher and student behaviors which were directly related to the implementation process. A procedure was designed to maximize construct validity of the evaluation instruments. First, the philosophy and rationale of the selected science curricula were derived from descriptive, instructional, and evaluative materials on the curriculum development projects. Wherever possible, direct communication was entered into with project directors, curriculum workshop leaders, curriculum writers, master teachers, and others highly knowledgeable about the new curricula in general and the selected curricula in particular. Some of these resource people served as consultants to the project; from the information collected, teacher and student behaviors directly related to successful implementation of the innovative science curricula were derived.

The next step involved identifying the observable behavioral cues from which it seemed reasonable to infer the presence of these ideal or antithetical teacher and student behaviors.

Observations were made of teacher and student behaviors in several IPS and CHEM Study lecture-discussion and laboratory classes. Eight classes in four different schools were selected for videotape recording. These classroom observation data and the videotape recordings were analyzed, and from them, behavioral cues for coding cues for coding evidence of relevant teacher and student classroom behaviors were identified. These behavioral codes were refined by comparing the coding and interpretations of three independent observers and then refining the behavioral descriptions and cues in accordance with the critiques of the consultants.

The resulting behavioral codes were written into an observational form for use as a guide and check sheet. This sheet was then used for coding teacher and student behavior that seems to either facilitate or tends to interfere with the achievement of objectives consistent with the goals of the new science curricula in general, and the selected curricula in particular. The guides are shown in Appendices G and H.

Procedure. As the second phase of this study, an intensive evaluation was made of the implementation of IPS and CHEM Study classes. In an evaluation study, there is little control over certain important variables. Among these are variables relating to sampling. The original plan was to select evenly a total of 30 schools representing the following categories:

1. Heterogeneous populations from urban, suburban, and rural areas.
2. Urban schools having a large proportion of culturally disadvantaged children which had used the new curriculum for at least two years.
3. Randomly selected schools which had adopted the curriculum less than two years ago.
4. Randomly selected schools which had recently abandoned the curriculum.

In actuality, two curricula were selected for study, thereby enhancing the opportunity to examine articulation problems. Thus, an attempt was made to select CHEM Study schools into which IPS schools fed. But sample selection was severely limited by the small number of schools identified as using IPS (61 schools). Furthermore, in few of these schools, did we find teachers having over two years experience with the curriculum (14% of the teachers).

Only two schools were identified as having abandoned either curricula, and in the case of an IPS school, abandonment was found to be the result of administrative problems (i.e., the teacher was transferred) rather than being a matter of choice.

Within these limitations, a sample as widely divergent as possible was selected based upon type of community, socio-economic level, student ethnic background, and school size. An attempt was made to include schools which had newly adopted these curricula and schools which had used them since their initial appearance.

Altogether, 61 schools were visited in 18 California counties and six schools in three Nevada counties for a total of 67 schools. Of these, 17 were junior high or intermediate, and 50 were senior high schools.

Dissemination Phase

Some of the findings from this study have been presented to science teachers and supervisors at National Science Foundation Summer Institutes at the University of California, Berkeley, and Southwest Regional Conferences. Detailed data, science curriculum materials and personnel resource files may be examined at the

Laboratory. A Final Report has been submitted to the National Science Foundation. A limited number of copies of the Final Report and the Technical Report are available upon request to interested school personnel.

THE INTERMEDIATE SCIENCE PROGRAM

This section deals with science programs designed for use in intermediate grades seven through nine. These programs usually are oriented toward the physical sciences although some topics in biological science may be treated.

Science curriculum development at the intermediate school level encountered some basic problems of mechanics which were not as severe at the upper secondary level. Intermediate science was generally considered by school authorities to require fewer laboratory experiences and schools often lacked science laboratories. The instructional staffs of intermediate and junior high schools seldom included teachers who were well prepared specifically in the exact sciences.

Curriculum development efforts have been directed largely toward devising ways of coping with the existing school conditions. Course content and laboratory experiences have been carefully selected and, in some cases, laboratory equipment units were designed to minimize the personnel and school plant requirements for use of these new curricula.

Even so, teachers have been confronted with a variety of problems in introducing these new curricular materials into the existing school program. Their experiences are presented in this section after a brief description of the teacher sample with respect to experience and special preparation in the use of the specific curriculum.

Teacher Experience and Special Preparation

Approximately two-thirds of the intermediate science teachers had less than two years experience, while less than five percent had over five years experience with the given curriculum. Approximately half of the teachers did not have special preparation for teaching the specific course. The sole exception was teachers who were involved from early developmental stages in the Interaction of Matter and Energy (IME) course. However, half of the Earth Science Curriculum Project (ESCP) teachers and approximately a third of the Time, Space, Matter (TSM) and Introductory Physical Science (IPS) teachers had received over ten class hours of special preparation. These data are presented in Table 3.

For all the innovative curricula and curricular improvement materials reviewed, inexperienced teachers tend to have no special preparation while experienced teachers tend to have appreciable preparation. Specifically, of teachers with less than two years experience in using the new science curricular materials, 53% had no special preparation, and only 35% had over ten classroom hours special preparation. In contrast, among teachers having over two years experience, only 29% had no special preparation while 67% had over 10 class hours of special preparation in the use of the new curricular materials. Notable exceptions are found with ESCP and IME teachers. Forty-nine percent of the ESCP teachers and 54% of IME teachers with less than 2 years experience had over 10 class hours of special preparation. Data from teachers using the Inquiry Development Program (IDP) materials are included in Table 3 for purposes of comparison.

Table 3

EXPERIENCE AND SPECIAL PREPARATION OF TEACHERS OF INTERMEDIATE SCIENCE

Percentages of Teachers Within Each Category

	Length of Experience					Special Preparation		
No. of Teachers	One Semester	Less Than One Year	1 to 2 Years	Over 2 Years	Curricular Materials	None	Under 10 Class Hours	Over 10 Class Hours
					New Curriculum			
52	40	21	21	17	ESCP	42	8	50
14	14	57	7	21	TSM	64	0	36
59	46	20	20	14	IPS	56	12	32
					Other New Materials			
21	43	19	24	15	IDP	48	33	19
14	50	14	29	7	IME	29	14	7

Implementation Problems Encountered by Teachers

Taking the entire spectrum of problems presented as forced-choice items on the questionnaire (see Teacher's Questionnaire, page 2 in Appendix C) the proportion of teachers designating each problem as "moderate" or "very serious" was calculated.

Approximately three-quarters of the teachers of innovative curricula (ESCP, TSM, and IPS) reported moderate or serious problems with students' skills in problem-solving and math background, as applied to science.

About 50% of the teachers found laboratory space and equipment inadequate for easily teaching a laboratory-oriented science program. An even larger percentage (50% to 66%) of intermediate school teachers agreed with the high school teachers on the need for additional teacher preparation time for conducting laboratory-oriented courses.

Although suitability of curriculum did not pose the problem that either school organization or student preparation did for the teachers, approximately 50% of the ESCP, TSM and IDP teachers commented on the expense of equipment and material. This is probably related to the fact that laboratory equipment expense in many junior high schools is a relatively new budget consideration.

The questionnaire items which 30% or more teachers considered a moderate or very serious problem are shown in Table 4, with the percentage of teachers giving these responses.

Teacher Needs for Effective Implementation

Because of the recent adoption of laboratory science curricula in many elementary and intermediate schools, school personnel

Table 4

INTERMEDIATE SCIENCE TEACHERS' REPORT ON MODERATE AND VERY SERIOUS PROBLEMS

Most Predominant "Moderate" and "Very Serious Problems"	Percentage of Teachers for Each Problem Item				
	New Curriculum			Other New Materials	
	ESCP *N=55	TSM N=14	IPS N=59	IDP N=20	IME N=14
Student Preparation					
Math Background of most students is too low.	74	71	81	35	43
Reading level of most students is too low.	67	36	53	45	36
Generally, the students lack an adequate basic knowledge of science.	44	36	39	50	22
Most students lack sufficient skills in using scientific methods of problem-solving.	74	88	71	80	64
Generally, students are not sufficiently adept at handling laboratory apparatus.	54	57	42	55	36
Most students have had inadequate elementary or junior high school science courses.	56	50	37	40	21
Suitability of Materials					
Often these materials don't provide for adequate development of basic concepts.	26	14	12	35	36
The required materials are too expensive.	46	57	22	45	7
School Organization					
Laboratory space or furniture is inadequate for desired student experimentation.	48	50	44	50	14
Laboratory equipment or material is inadequate for sufficient student experimentation.	58	28	22	45	14
School scheduling does not permit a sufficient block of time for science classes.	43	22	53	30	14
Insufficient time is provided for science teachers to plan and prepare for lab sessions.	56	50	66	50	43

*N=Total number of responses.

may tend to focus their attention on problems close to them. In order to widen perspective regarding teacher needs for effective implementation, both teachers and principals were asked their views. These findings are reported separately in the following paragraphs.

Ranking of Needs by Teachers

Intermediate science teachers were asked to rank five needs of most teachers relative to enhancing successful implementation of new science curricula. The needs for stronger subject matter background and special instruction were greatest for ESCP teachers; the needs to observe the curriculum being taught and to have stronger subject background were greatest for TSM teachers; and for IPS teachers the greatest needs were for extra preparation time and special instruction. The lowest need was for consultant help except in the use of IME materials where this was the teachers' greatest need.

The percentage of teachers giving ranks 1 or 2 to each of the five listed needs are shown in Table 5 for the innovative curricula and course improvement materials.

Indications of Teacher Needs by Principals

Principals of elementary and junior high schools regard teachers' need for information on new science curricula as greater than their need for a stronger science background, responding 56% and 44% respectively. This was especially true of schools of less than 500 students where twice as many principals expressed the former concern as the latter. Principals of urban and large urban schools regard these needs as equal.

Table 5

INTERMEDIATE SCIENCE TEACHER'S NEEDS FOR EFFECTIVE IMPLEMENTATION

Teacher Needs	Percentage of Teachers Reporting Rank 1 or 2				
	New Curriculum			Other New Materials	
	ESCP *N=48	TSM N=15	IPS N=60	IDP N=21	IME N=11
Need for SPECIAL INSTRUCTION	50	30	47	62	36
Need to OBSERVE CURRICULUM BEING TAUGHT	32	61	38	61	36
Need for EXTRA PREPARATION TIME	29	38	76	24	54
Need for CONSULTANT HELP	21	30	18	28	73
Need for STRONGER SUBJECT MATTER BACKGROUND	64	40	21	28	36

*N = Total number of responses

Most Crucial Problems in Science Curriculum Development

A content analysis of responses to the open-ended questionnaire item asking intermediate level teachers for their view of the most curcial problems relative to science curriculum development is summarized in Table 6. This summary reveals that their primary concern was with the need both for adequate science programs for diverse student groups and for better articulation of existing courses with the science program at other levels. Of somewhat lesser importance were the needs for adequate teacher education, more teacher preparation time, improvement in school facilities, and methods for increasing student motivation and understanding. Exceptions to this general ranking were found in the responses of teachers using the Inquiry Development Program (IDP), which is not designed as a full year course, and of teachers using the newly adopted California state series Concepts in Science by Paul F. Brandwein. For the IDP teachers, training in the new methods of inquiry was of greatest need, while those teachers using the state series indicated predominately the need for new plant facilities.

Table 6

INTERMEDIATE SCIENCE TEACHERS' VIEW OF MOST CRUCIAL PROBLEMS IN SCIENCE CURRICULUM DEVELOPMENT

	Percentage of Teacher Responses					
	New Curriculum			Other New Material		
Categories of Most Predominant Problems	ESCP *N=60	TSM N=21	IPS N=67	IDP N=25	IME N=18	State Series N=47
Need for Increase in Student Motivation, Ability, Achievement, and Understanding	13	5	7	8	11	13
Need for Programs or Materials for Slow Learners and Students with Learning Difficulties	17	19	16	0	11	13
Need for Better Articulation with Lower and Higher Grade Courses	12	5	21	8	11	11
Need for Improvement in School Plant Organization; in Space, Equipment, Facilities	13	10	7	8	17	21
Need for Teacher Preparation, Background Information, Inquiry Skills; Higher Quality of Teachers	18	19	9	28	17	8
Need for More Teacher Preparation Time and Money to Purchase Materials	7	29	10	12	22	11
Need for Clearer Statement of Objectives; Balance Between New and Traditional Science	12	5	10	24	6	10
Other Needs: Emphasis on Process; More Evaluation of Curriculum; More Teacher and Community Understanding of Programs	8	5	9	16	6	12

*N = Total number of responses

**State Series = The California State adopted textbook series "Concepts in Science" by Paul F. Brandwein

THE FIRST YEAR BIOLOGICAL SCIENCE PROGRAM

Biological Science Curriculum Study (BSCS) writers approached the problem of varied teacher and student preparation and diverse local teaching situations by producing four alternative biology courses. The blue, green, and yellow versions present the study of biology from different conceptual approaches. These approaches are molecular, ecological/behavioral, and unity/diversity/continuity, respectively. The fourth course, Special Materials, was developed for less able students.

The experiences of teachers in implementing the BSCS curricula are presented in this section after a brief description of the teacher sample with respect to experience and special preparation relative to these four biology courses.

Teacher Experience and Special Preparation

Two-thirds of the Blue Version teachers and more than half of the Green and Yellow Version teachers had over two years experience teaching their respective versions. Less than a quarter of the Special Materials teachers fell into this category, a third having one to two years experience and another third of whom were first-semester teachers.

Seventy percent of the Blue Version and approximately half of the Green and Yellow Version teachers had 10 hours or more special preparation for teaching their respective BSCS course. However, only 39% of the Special Materials teachers had 10 hours or more special preparation and 43% had none. Table 7 presents these data.

Table 7

EXPERIENCE AND SPECIAL PREPARATION OF TEACHERS
OF BSCS FIRST YEAR BIOLOGY

Percentage of Teachers Within Each Category

Number of Teachers	Length of Experience: One Semester	Less Than One Year	1 to 2 Years	2 to 5 Years	Over Five Years	BSCS Curriculum	Special Preparation: None	Under 10 Class Hours	Over 10 Class Hours
95	14	4	14	50	17	Blue Version	24	5	70
94	11	10	22	51	4	Green Version	46	10	45
102	15	10	21	46	10	Yellow Version	37	11	52
44	34	12	33	23	0	Special Materials	43	18	39

Generally, the lower the experience a BSCS teacher has had in teaching this curriculum the less special preparation he has had. This was especially true among Yellow Version and Special Materials teachers. Forty-nine percent of teachers with less than two years' experience had no special preparation and 42% had over 10 class hours of preparation. However, 60% of teachers having over two years experience had over 10 class hours of preparation while only 29% had no special preparation.

The median experience of BSCS teachers was two to five years except for Special Materials teachers whose median experience was one to two years.

Blue Version teachers had the greatest amount of special preparation and Special Materials teachers had the least amount.

Implementation Problems Encountered by Teachers

Responses to 16 questionnaire items in the areas of student preparation, school plant or organization, and suitability of curriculum were obtained for teachers of each BSCS Version.

The most predominant problem for all BSCS teachers was the students' lack of sufficient skill in using scientific methods of problem-solving. The next three greatest problems were: (a) the low reading level of all students except those using the Blue Version, (b) the low mathematics background of students using Special Materials, and (c) the lack of sufficient time either as a block for science classes or for teachers' preparation for laboratory sessions, especially for teachers using the Blue, Green and Yellow versions.

Suitability of curriculum presented little problem for BSCS teachers. The ten most predominant problems are shown in Table 8 with the proportion of teachers citing the problems as "moderate" or "very serious."

Teacher Needs for Effective Implementation

A comparison was made of the ranking by BSCS teachers of five specific needs relating to teacher preparation and assistance. The percentage of teachers of each version and Special Materials giving each need a rank of 1 or 2 are given in Table 9.

Blue and Yellow Version teachers predominately ranked as 1 or 2 the need of most teachers for an especially strong subject matter background, while Green Version and Special Materials teachers believed the greatest need for most teachers was to have extra time to work out lessons. Blue and Special Materials teachers considered the need of most teachers for special instruction in their specific version as ranking second while Blue Version teachers ranked strong subject matter background as second. Only Yellow Version teachers regarded the need for consultant help as great, and these teachers gave it second priority.

Most Crucial Problems in Science Curriculum Development

A content analysis made of responses to the open-ended questionnaire item asking for the teacher's view of the most crucial problems relative to science curriculum development today is summarized in Table 10. Teachers of BSCS Green and Yellow Versions found the most predominant single problem reflected the lack of

Table 8

BSCS FIRST YEAR BIOLOGY TEACHERS' REPORT ON MODERATE AND VERY SERIOUS PROBLEMS

Most Predominant Moderate and Very Serious Problems	Percentage of Teachers for Each Problem Item for Each BSCS Version			
	Blue *N=95	Green N 94	Yellow N=102	Special Materials N=44
Student Preparation				
Math Background of most students is too low.	37	42	34	74
Reading level of most students is too low.	46	71	65	71
Most students lack sufficient skills in using scientific methods of problem solving.	81	84	75	75
Generally, students are not sufficiently adept at handling laboratory apparatus.	54	42	53	49
Generally, students lack an adequate basic knowledge of science.	54	52	64	52
Most students have had inadequate elementary or junior high school science courses.	53	51	57	53
School Organization				
Laboratory space or furniture is inadequate for desired student experience.	53	51	54	35
Laboratory equipment or material is inadequate for sufficient student experimentation.	40	48	54	31
School scheduling does not permit a sufficient block of time for science classes.	70	65	62	33
Insufficient time is provided for science teachers to plan and prepare for laboratory sessions.	68	63	75	55

*N = Total number of responses

Table 9

BSCS FIRST YEAR BIOLOGY TEACHERS'
NEEDS FOR EFFECTIVE IMPLEMENTATION

Teacher Needs	Percentage of Teachers Reporting Rank 1 or 2 BSCS Version			
	Blue *N=89	Green N=81	Yellow N=94	Special Materials N=41
Need for SPECIAL INSTRUCTION	56	48	44	52
Need to OBSERVE CURRICULUM BEING TAUGHT	16	20	19	49
Need for EXTRA PREPARATION TIME	53	62	20	59
Need for CONSULTANT HELP	8	15	65	13
Need for STRONGER SUBJECT MATTER BACKGROUND	75	59	67	33

*N = Total number of responses

Table 10

BSCS FIRST YEAR BIOLOGY TEACHERS' VIEW OF MOST CRUCIAL PROBLEMS IN SCIENCE CURRICULUM DEVELOPMENT

Categories of Most Predominant Problems	Percentage of Teacher Responses BSCS Version Blue *N=130	Green N=110	Yellow N=107	Special Materials N=53
Need for Increase in Student Motivation, Ability, Achievement and Understanding	13	12	15	19
Need for Programs or Materials for Slow Learners and Students with Learning Difficulties	14	21	18	19
Need for Better Articulation with Lower and Higher Grade Courses	18	17	9	4
Need for Improvement in School Plant Organization; in Space Equipment, Facilities.	7	9	8	11
Need for Teacher Preparation, Background Information, Inquiry Skills; Higher Quality of Teachers	12	7	8	9
Need for More Teacher Preparation Time and Money to Purchase Materials	14	5	10	15
Need for Clearer Statement of Objectives; Balance Between New and Traditional Science	9	10	9	2
Other Needs: Emphasis on Process; More Evaluation of Curriculum; More Teacher and Community Understanding of Program	14	17	24	22

*N = Total number of responses

programs designed for special groups of students. This was expressed even by teachers using Patterns and Processes, BSCS's text for slow learners. The problems of articulating BSCS with other science courses and of student motivation were outstanding concerns. Adequate teacher preparation time to organize the laboratory and teacher training were also of concern to many teachers.

THE ADVANCED SCIENCE PROGRAM

Traditionally, chemistry and physics have been offered as advanced science courses in the senior high school. In a few schools other advanced courses such as advanced biology, physiology, mechanics, technical chemistry or electronics may also be offered. At these grade levels, science is usually an elective subject which enrolls less than half of the student body of a school. The students who do enroll tend to be either college preparatory students fulfilling a requirement for college entrance or scientifically adept students. The CHEM Study, PSSC physics, and Advanced BSCS biology courses are aimed primarily at this select group and are dealt with in this section. The description of teachers of these courses and their experiences in using these curricula are presented in the following sub-section.

Teacher Experience and Special Preparation

Approximately 70% of the CHEM Study and PSSC physics teachers, but only one fourth of Advanced BSCS biology teachers, had over two years experience in teaching these curricula. Twelve to 16% of the PSSC physics and CHEM Study teachers had less than a year's experience in teaching these curricula, compared with 42% of the advanced BSCS teachers.

About 60% of the CHEM Study and PSSC physics teachers had over 10 class hours of special preparation while a third had none, whereas less than half of the Advanced BSCS biology teachers had over 10 class hours of special preparation and over half had none. These data are presented in Table 11.

Table 11

EXPERIENCE AND SPECIAL PREPARATIONS OF TEACHERS OF ADVANCED SCIENCE

Percentage of Teachers Within Each Category

	Length of Experience						Special Preparation		
Number of Teachers	One Semester	Less Than One Year	1 to 2 Years	2 to 5 Years	Over Five Years	Curriculum	None	Under 10 Class Hours	Over 10 Class Hours
188	7	9	14	54	17	CHEM Study	30	6	64
123	6	6	20	41	28	PSSC Physics	37	3	59
17	18	24	35	18	6	Advanced BSCS Biology	53	0	47

Implementation Problems Encountered by Teachers

The spectrum of problems on the Teachers' Questionnaire provides a detailed view of specific concerns of teachers of advanced sciences. Responses to the sixteen questionnaire items in the areas of student preparation, school plant or organization, and suitability of curriculum reflect differences in two areas. The major problems in each area were almost the same for all three advanced curricula. However, the responses reflect differences with respect to the student populations in and student capabilities required for advanced science, first-year biology, and intermediate science courses. The upper level courses demand much more use of mathematics than do any of the lower level courses, and half to over three quarters of the teachers reported that this is a moderate to serious problem. Over half of the teachers of PSSC physics classes reported that even their highly selected students have problems in this area. Low problem-solving skills or low ability in reasoning from the laboratory experience towards the development of concepts was seen as at least a moderate problem for students of two thirds to three fourths of the teachers. Inadequate teacher preparation time for the laboratory, and insufficient class time to permit students to complete laboratory activities in a class period were at least moderate problems for half to almost three quarters of the teachers, although less than a third of this number reported these as very serious problems. The reading level of the students remained a problem, particularly in CHEM Study (according to 60% of the teachers) where the students are not so highly selected as they are for either PSSC physics or Advanced BSCS biology. Interviews with teachers about students' reading problems indicated that the primary problem was that of reading for information in the sciences and reading directions for the laboratory with adequate understanding. These responses did not reflect a low reading level for general (non-scientific) material.

Again, very few of the "moderate" or "serious" problems fell in the general area of suitability of curriculum. However, over 40% of the advanced BSCS biology teachers felt that these materials did not provide for adequate development of basic concepts. They ranked this item sixth along with two other items concerning laboratory equipment inadequacies and students' general lack of adequate basic knowledge in science. The findings are presented in detail in Table 12.

Teacher Needs for Effective Implementation

Of the five questionnaire items relating to the kinds of help needed by teachers of new science curricula in general, only two were ranked either 1 or 2 by half of the teachers: The teachers of upper level science courses indicated that most teachers need a very strong subject matter background, and special instruction for the particular curriculum. A third or more of the teachers also gave high priority to the need for extra preparation time for teachers. These results are shown in Table 13.

Most Crucial Problems in Science Curriculum Development

Table 14 presents the results of a content analysis of responses made by advanced science teachers to the open-ended questionnaire item asking their view of the most crucial problems relative

Table 12

ADVANCED SCIENCE TEACHERS' REPORT ON MODERATE AND VERY SERIOUS PROBLEMS

Percentage of Teachers for Each Problem Item

Most Predominant "Moderate" and "Very Serious" Problems	CHEM Study *N=189	New Curriculum PSSC Physics N=122	Advanced BSCS Biology N=17
Student Preparation			
Math background of most students is too low.	78	53	71
Reading level of most students is too low.	60	41	18
Most students lack sufficient skills in using scientific methods of problem solving.	74	65	76
Generally the students lack an adequate basic knowledge of science.	43	31	41
Most students have had inadequate elementary or junior high school science courses.	49	38	12
Suitability of Curriculum			
Often these materials don't provide for adequate development of basic concepts.	22	16	41
School Organization			
Laboratory space or furniture is inadequate for desired student experimentation.	23	38	35
Laboratory equipment or material is inadequate for sufficient student experimentation.	21	27	41
School scheduling does not permit a sufficient block of time for science classes.	53	58	65
Insufficient time is provided for science teachers to plan and prepare for laboratory sessions.	62	72	59

*N = Total number of responses

Table 13

ADVANCED SCIENCE TEACHERS' NEEDS FOR EFFECTIVE IMPLEMENTATION

Percentage of Teachers Reporting Rank 1 or 2

Teacher Needs	CHEM Study *N=166	PSSC Physics N=108	Advanced BSCS Biology N=16
Need for SPECIAL INSTRUCTION	52	58	50
Need to OBSERVE CURRICULUM BEING TAUGHT	9	11	6
Need for EXTRA PREPARATION TIME	31	36	38
Need for CONSULTANT HELP	8	9	19
Need for STRONGER SUBJECT MATTER BACKGROUND	46	44	62

*N = Total number of responses

Table 14

ADVANCED SCIENCE TEACHERS' VIEW OF MOST CRUCIAL PROBLEMS IN SCIENCE CURRICULUM DEVELOPMENT

Categories of Most Predominant Problems	Percentage of Teacher Responses: Advanced BSCS Biology *N=20	CHEM Study N=228	PSSC Physics N=139
Need for Increase in Student Motivation, Ability, Achievement, Understanding	15	18	14
Need for Programs or Materials for Slow Learners and Students with Learning Difficulties	5	28	23
Need for Better Articulation with Lower and Higher Grade Courses	20	16	19
Need for Improvement in School Plant Organization; in Space, Equipment, Facilities	0	3	4
Need for Teacher Preparation, Background Information, Inquiry Skills; Higher Quality of Teachers	30	11	6
Need for More Teacher Preparation Time and Money to Purchase Materials	5	7	6
Need for Clearer Statement of Objectives; Balance Between New and Traditional Science	15	7	11
Other Needs: Emphasis on Process; More Evaluation of Curriculum; More Teacher and Community Understanding of Program	10	9	17

*N = Total number of responses

to science curriculum development. The most predominant problem for CHEM Study and PSSC physics teachers reflected the need for special programs for low achieving students, while advanced BSCS teachers indicated the greatest need was for better prepared higher quality teachers.

The need for better articulation with lower and higher grade courses and the need for better student motivation led to the second and third highest ranking problems for teachers of advanced science courses.

EVALUATION OF NEW SCIENCE CURRICULA

Summary of Teacher Evaluations

Sixty to eighty percent of the responses to the questionnaire item put to teachers concerning strengths of specific new science curricula or curricular materials related to two strengths: the laboratory or inquiry approach and conceptual organization of the curricular materials. Intermediate science teachers especially suggested that these curricula challenged and motivated students of many different abilit, ,evels. BSCS Special Materials teachers indicated that the usefulness of this course for special student subgroups was as great a strength as its conceptual approach. BSCS and advanced science teachers ranked as third greatest strength the factual accuracy of the subject matter and treatment of current theory in the new curricula.

Generally, science teachers found weaknesses in the use of these curricula with different student groups, and they recommended either smaller classes or that enrollment be limited to particular student groups. Intermediate teachers recommended that they be allowed morr time for preparation for the laboratory sessions. Some BSCS teachers felt that changes need to be made in the course content to better relate it to students' background by supplementing it with new materials and improving the correlation of the textbook and the laboratory exercises. CHEM Study and Advanced BSCS biology teachers recommended that changes be made in students' preparation for these courses. In fact, these teachers having students who had taken IPS were enthusiastic in recommending it as a good preparatory course. PSSC physics teachers indicated that better integration of the course material is needed and agree with Advanced BSCS biology teachers that certain subject matter modifications would improve the courses.

Summary of Classroom Observations and Interviews

The observational guides and interview schedules previously described were used during visitations of IPS and CHEM Study classes. Data obtained on these were compiled and a summary of the findings forms the basis for this section.

Introductory Physical Science

Introductory Physical Science (IPS) is used in California schools for two distinct groups of students. At the intermediate school level, primarily in grades eight and nine, it provides a basis for future science courses. At the senior high school level, in grades 10, 11, and 12, it usually serves as a terminal science course for students often of lower motivation or ability in the sciences. In both groups, students were apparently learning from the course on various levels including the intellectual, the mechanical, the concrete operational, and for some even the abstract operational levels.

Between 10% and 20% of those high school students who took the course as either 10th or 11th graders became so interested in science that they elected or intended to elect another course the following year. Teachers who were currently teaching a few of these students in either a biology or chemistry class felt that IPS was a "life saver" for these students and that it generally made "B or better" grade students out of marginal "C" grade students.

The instruction and practice students received in writing up laboratory experiments, graphing and interpreting graphs was particularly useful in biology. Instruction and practice in the application of basic mathematics (such as ratios and proportions, powers of ten), in scientific notations approximation, in chemistry laboratory experimentation and in the interpretation of laboratory results were most helpful to chemistry students. No physics teachers of students who had taken IPS were interviewed.

Several physics and chemistry teachers who were teaching an IPS course and anticipated having some of these students later felt that one bonus of the course was the insight it gave them as teachers into the conceptual problems of students in the more advanced courses. They were currently changing their teaching techniques or explanations in CHEM Study or PSSC physics courses to those they found to be so successful with their IPS students.

Teachers found several weaknesses in the IPS course package as it related to their students or their school. The equipment packages are not as self-contained as they were represented to be. Thus, while they made possible the conversion of a regular classroom to a laboratory, the equipment was not complete enough to be used without supplementary supplies for a class of 30. This often occurred because the junior high school was not equipped with even ordinary science supplies such as extra alcohol, rubber tubing, test tubes, beakers and thermometers to take care of extra needs and breakage. Thus, experiments sometimes had to be delayed or run with larger sized laboratory groups than desired because of the lack of adequate supplies.

Both intermediate and senior high school teachers found that the reading level of the textbook was too high for some of their students. Some suggested that much of the information in the teacher's guide on laboratory techniques, data reporting and understanding graphs could well have been included in the student text or in a supplementary handbook so that the students would have a reference guide to help them in later experiments. According to observations during this study, after the first four or five chapters were finished most of the students did use the text or their laboratory notebook as just such a reference guide to old experiments which they thought might have some bearing on the experiment they were performing.

Teachers of 10th and especially 11th or 12th graders usually needed to adapt the course extensively, extending the pre-laboratory sessions to develop, often concretely, the mathematics the students needed in the laboratory. Half or three-fourths of the students in some of these classes, for instance, did not know the formula for finding the area of a circle. In addition, post-laboratory discussions, problems at the end of the chapters, and tests needed to be much more concrete for many of these students.

Teachers generally liked the end-of-chapter Home, Desk and Lab Section. They found it helpful in keeping all classes together, the best students doing most of these problems and the poorest students doing few or none. However, they felt a need for supplementary laboratory experiments both for better students to perform while they waited for the rest of the class to catch up with them and for poorer students who needed additional appropriate experience in order to adequately develop a concept. In addition, short films at a simple level on concepts and techniques developed or used in IPS would have been most valuable. None of the teachers had found any films available in the physical sciences which met this need.

The IPS teachers interviewed seemed better qualified than general science teachers are on the whole. They usually had a major in either chemistry or physics, or, if they were biologists, a good background in the physical sciences as well. They were interested in their students, in curriculum, articulation, and innovation in general. About two-thirds of these teachers had initiated the use of IPS at their schools.

Interviewees included two teachers who had dropped the IPS course and one who was definitely unhappy with it. All three of these teachers were biologists with little physical science background and felt rather insecure in handling the course. In one of the schools where teachers were encouraged to have students sitting at their desks most of the time, IPS students did not do so. In one school the administration had assigned the teacher who had introduced the course to teach a class in a different subject area because of the heavy enrollment of students in that department. In the third case, the teacher planned to teach IPS again the following year, but had been unable to keep up with the laboratory preparation this year because he was teaching four different additional courses.

Preparation time for student laboratories, dry-running the laboratory experiments for first-time teachers of IPS, and make-up labs were real problems unless the teacher had either a qualified student or adult assistant, or unless he shared the load with another teacher in the department. Two schools visited had departmental science or mathematics-science laboratories for make-up experiments. These were staffed during all periods and for a short time after school by one or more members of the department who could help students making up laboratory work.

In two schools, team teaching was practiced by two teachers, each one setting up and teaching only half of the laboratories and shifting the students back and forth between them. This kind of cooperation was even effective as a variation of inservice education in that a new teacher learned to handle many problems in teaching the course while team-teaching with a teacher exoerienced in using the new curriculum.

Chemical Education Materials Study

Generally CHEM Study teachers felt that this course was not designed for all of their students and should be taken by only those of average or above-average ability. They agreed that the laboratory-based activities of the course made it much more valuable to their average students than the old traditional style course. However, they felt that the material was covered too fast and was too high powered for the average or below-average student. They stressed the need for another course like CHEM Study which would move at a slower pace, and would include much of qualitative analysis chemistry in a format designed to develop problem-solving skills and processes in the students.

Supplementary material written at a high school level on current problems of the world which are of interest to applied as well as theoretical chemists would also help to relate either CHEM Study or a new course to students in general.

About 50% of the teachers felt that students should study some physics prior to taking chemistry so that the kinetic theory and atomic models for chemical reactions would be much easier to understand. Two schools were experimenting with their own variation of the Portland Project physics and chemistry two-year course in an attempt to integrate these subjects. The major problem with such a course, however, was that only the scientifically talented students would elect to take two years of science at this level. Two teachers interviewed had several students in their classes who had taken IPS two years before. These teachers felt that this course gave the students a minimum physics background as well as the basic mathematics, laboratory techniques and inquiry training (problem-solving experience) necessary for the chemistry course.

CHEM Study teachers expressed concern over the scheduling of their class time. Whereas, having enough time to prepare for the laboratory exercises was not as great a problem for them as it was for IPS teachers, inadequate class time to efficiently schedule laboratories and laboratory discussions was of great concern. Even teachers in two schools with "flexible modular scheduling" revealed this problem. A few teachers expressed hope that in the future, when the majority of their students would have an adequate background in laboratory techniques and problem-solving, this would be less of a problem. Whether IPS training of a majority of CHEM

Study students would solve this problem is a moot question. It is anticipated that ten of the chemistry teachers interviewed will have classes of IPS-experienced students this year.

Teachers of the CHEM Study classes represented a much broader spectrum of teacher capabilities and backgrounds than did the IPS teachers. They seemed less innovative and probably more representative of science teachers generally. Some were mature persons who had recently come to the classroom from industrial or military careers. Some were teachers with biology or physics majors and relatively little chemistry background. Many felt a need for inservice education in the new methods of developing student inquiry, and for aids to help them handle new curricula. Those teachers with little recent science education also felt the need for updating their subject matter background on some of the current theoretical explanations of chemical phenomena.

RECOMMENDATIONS

Interviews with administrators and science teachers in 61 junior and senior high schools in Northern California and Nevada revealed that school personnel were vitally concerned with problems of student motivation, preparation and ability differences; these problems included teacher recruitment and preparation, scheduling and organizing school time and facilities, development of various new science programs and their articulation with existing programs in the school. Questionnaire and interview data as well as the observation of various practices provided insight into the implementation process and seemed to suggest certain practices as critical to the effective implementation of an innovative science program. These practices require cooperative efforts at both the district and school levels.

Procedures which depend more heavily upon district support are presented in the first part of this section. Suggestions for both district and school level administrators are included in the discussions. Practices which depend largely upon in-school adjustments and can be carried out by school principals and teachers are presented in the second part of this section.

Recommended Administrative Practices

School district practices which seem critical for effective implementation of new science programs are:

1. Providing special assistance and support to school personnel involved in curriculum development.
2. Providing assistance in obtaining research and resource materials for curriculum decision-making.

3. Providing support for a total plan of curriculum action to meet the needs of all students.
4. Providing for appropriate inservice teacher education.
5. Providing for continuing evaluation and curriculum revision.

These are dealt with in detail in the following pages.

Providing Special Assistance and Support to School Personnel Involved in Curriculum Development

Most curriculum innovation in the schools visited during this study was instigated by one or two faculty members in the school. This was true whether or not the innovation concerned the adoption of an already written program or the designing of an entirely new curriculum by the teacher. School administrators, scientists, civic groups or even other teachers usually were not involved in the initial efforts. In several situations of this kind, the new programs were dropped or drastically changed when the teacher subsequently left the school or was reassigned to teach other courses. At the school or department level, administrators can facilitate innovation by encouraging and supporting the pioneering teacher in his curriculum development efforts. Principals or department heads can reassign teaching responsibilities as well as preparation periods in order to give the teacher the necessary time for laboratory preparation and evaluation of the new features of the program. For example, a double preparation period immediately preceding or following a lunch period may be much more useful for trouble shooting or building equipment than two single preparation periods. When two teachers are involved in developing the same course, regularly scheduled concurrent preparation periods during the school day are often more productive for thrashing out problems together than only irregular periods after school. Further, administrators can reduce teaching loads of pioneering teachers for a semester or two, making available paraprofessional teacher aides either as paid or volunteer assistants especially for laboratory preparation and record keeping.

Many programs falter, because normal district procedures for purchasing school materials require anticipation of needs months in advance, or because budgets allow for major purchases for science classes in certain specified fiscal years. In an experimental program, equipment supply needs may not have been anticipated previously, yet without these materials at a critical time success of the program may be seriously jeopardized. At both the school and district level, administrators can initiate procedures for expediting procurement of materials and construction of necessary facilities (e.g., an extra sink can convert a junior high classroom into a rather adequate laboratory) toward facilitating the conduct of the experimental program.

An important role administrators can assume is to facilitate communication within the school and between the school and community. Even devoted teachers need encouragement and reinforcement through new information. Feedback of the ideas and experience of other teachers and students with the new curriculum and of other interested people in the community is especially useful. Administrators may find it advisable to keep parents, students and other teachers informed of the innovative experimentation with respect to its validity, expected outcomes, and results. Administrators can also be instrumental in identifying in the school or community other potential leaders interested in innovation and bring these talented, interested teachers, parents and scientists together to plan and develop modifications of the existing curriculum.

Providing Assistance in Obtaining Research and Resource Materials for Curriculum Decision-Making

According to our findings, school curriculum committees seldom had access to the various research and resource materials needed in order to identify worthwhile ideas and suggestions for curriculum action efforts. In most of the schools teachers and department heads were able to assemble or look at only a few of the available commercial programs in the limited time available to them. Supplementary materials or laboratory equipment for a given program often were not seen before a program was adopted. Many teachers discovered problems with the design, quality or amount of such equipment only as they began to explore the course with their students. Ideas or materials from courses of study currently under development were not available either because of ignorance of their existence on the part of the study group, or because of lack of personnel time and money to discover them.

Appendix A lists some of the secondary school science programs currently under development nationally, as well as suggestions for sources of information on locally developed courses. Another source of information is the National Science Foundation Summer Institutes for science supervisors which survey new programs. At National

Science Teachers Association and California Teachers Association regional conferences, book exhibits provide opportunities for perusing new curricular materials. Science curriculum libraries being established at the Lawrence Hall of Science, University of California at Berkeley, and at California State College at Hayward, California are examples of local sources of these materials. The Laboratory's Integrated Information Unit (IIU) on Elementary Science Curricula provides school personnel with information helpful in selecting a curriculum that matches the needs and resources of a particular school and serves as a prototype for this kind of communication. District and school administrators would be enhancing the effectiveness of the school curriculum committee and individual school personnel involved in curriculum decision-making by making these materials more readily available to them.

Providing Support for a Total Plan of Curriculum Action to Meet the Needs of All Students

Most schools visited in this study were dealing with their curricular problems individually rather than attacking them with a total school plan. In only two districts was an intensive study currently underway. However, in several schools, individual science departments and teachers were studying the total sequence of courses at their high school, or various curriculum materials for a single course at a given level, or materials designed for a given group of students. The materials they selected would be used to augment the existing course sequence. None of the districts visited has as yet implemented a complete K-12 new science program, although one district was progressing toward the goal. Several districts were experimenting with varied sequences of courses at the high school level to make the science program more flexible, more comprehensive, more suitable to diverse student groups, and less wasteful of student time. These efforts consisted primarily of attempts to better articulate the science courses with each other to eliminate duplication, for example, combining course materials similar to the Portland Project materials for a two- or three-year sequence. Variations in the use of existing curricula such as Biological Sciences Curriculum Study, Chemical Education Materials Study, Physical Sciences Study Committee, and Harvard Project Physics was being tried.

Science teachers were attempting to go beyond the science department and either articulate their courses with courses in the mathematics departments or incorporate the teaching of certain mathematical concepts into their courses. Through these efforts a more complete but longer course--usually of two years--would develop. An example of such a course is one in which vectors, trigonometry, and approximation are taught, followed by the gas laws, useful in both new physics and new chemistry courses, and other selected topics in chemistry and physics.

Such efforts at developing a total science program would benefit from greater support by school administrators in order to overcome the problems of articulation intensified upon the adoption of a new curriculum.

A large number of the teachers and principals in our study spontaneously indicated that programs for special groups of students, particularly the terminal science student and the non-college bound student, were still a most crucial need. Teachers of these special students who were interviewed and whose classes were visited overwhelmingly praised the laboratory-centered approach for these student groups. In nine high schools laboratory-based courses like Introductory Physical Science (IPS), designed originally for the early secondary school years as a laboratory foundation for later courses in the sciences, or Earth Sciences Curriculum Project (ESCP) were being used at the tenth through twelfth grade levels for terminal science students. These curricula were often modified to accommodate both the usually lower mathematical ability of these students and their higher maturity level. However, teachers generally felt that these courses were not suitable for the upper high school students. A new course, Project in Terminal Science (PITS) is being developed specifically for older students and might be considered by curriculum groups faced with this need. Meanwhile, efforts should continue to be expanded in adapting materials to special student groups and supporting the development of curricula for them in order to make science courses available to all senior high students.

Where courses such as IPS and ESCP were used with seventh to ninth graders, teachers spoke highly of their flexibility in use with heterogeneous groups of students. Teachers indicated that students of lesser scientific ability could finish the years' work having learned some good laboratory techniques and with a feeling for the processes by which scientists collect data. Meanwhile, the more scientifically adept or experienced students would learn, in addition, something about the statistical basis for the developmental nature of scientific theories and the application of these theories to problems differing from those encountered in the laboratory. However, a few schools or districts were experimenting in developing a general science course for the ninth grade level which could be varied for students of different abilities. In these schools the same general concepts or processes were handled in all sections by all students but with activities varied according to students' ability. A student's entry into certain sections of later courses was to be determined by his grades in the beginning course as well as by the activity level he had attained. This kind of locally developed course also permits a more laboratory-conceptually oriented inclusion of topics such as drug abuse or health which may be required by either state law or local district edict. Thus, it must be recognized that the needs and requirements of students of each given school must be taken into account along with the time and money allowed for expenditure of efforts toward experimenting with a new course in order to learn how best to implement it in the given school or district.

Providing for Appropriate Inservice Teacher Education

Planning for adequate inservice education for science teachers is one of the most necessary, yet most frequently neglected, practices for successful implementation of new curricula. One view which needs to be overcome in order to plan such programs was revealed by administrators who speak of inservice education in terms of lecture or demonstration classes for large groups of teachers. Even where only two or three science teachers are involved in the curriculum innovation, their need for inservice education is a reality to be met through planning.

The provision of inservice education specific to a new curriculum prior to its installation is highly beneficial to the teachers involved, and considered a requirement by the developers of some curricula such as Introductory Physical Science. Yet, often teachers do not know that they will be teaching the new curriculum in time to plan to attend summer sessions at the nearest college or university or to apply for a National Science Foundation Summer Institute award prior to the spring deadline. As a result, teachers tend to attend summer institutes only after having started to teach the new curriculum.

Some districts and schools are cognizant of this problem and are taking measures to cope with it. In some instances schools and districts are maintaining close lines of communication with science teachers so that the latter are aware of the target date for installation of a new program and can plan to avail themselves of opportunities for special preparation. In adopting an innovation district-wide, one district provided an inservice workshop lasting several weeks during the summer prior to the installation of the new curriculum.

Even when inservice preparation has been acquired, an on-going inservice program is beneficial. A major problem in implementing an on-going inservice program is scheduling time when teachers can attend willingly, attentively, and regularly. A number of colleges and universities offer extension evening courses convenient for teachers in certain districts. Yet only a small percentage of the teachers usually take advantage of these programs because of other responsibilities during those hours. District inservice sessions held immediately before the school fall opening, after spring closing, or afternoons or evenings after school have usually been limited to a few sessions to minimize conflict with teachers' out-of-school commitments.

To overcome scheduling problems for an inservice program a few districts visited in this study experimented with an "assembly" schedule for the schools one day a week. The extra hour gained was used some weeks for student activities and some weeks for teacher inservice activities with students being dismissed early. Other districts occasionally provided for substitutes in order to release teachers for participating in day- or week-long institutes sponsored by the district or other institutions. Through arrangements such as these, whereby inservice sessions are held during normal working hours, sizeable numbers of teachers were able to attend.

Where only a few teachers were involved within a single school it was sometimes possible to schedule science teacher preparation periods to coincide at least one period per day so that ongoing inservice could then take place within the department. Provision of teacher assistance for laboratory-class preparation helped free teachers to attend to inservice education.

Where special inservice training is needed for only a few teachers, a district or school could make accessible to teachers newly developed self-instructional inservice education materials. Minicourses being developed at the Laboratory provide individualized teacher education in classroom skills and behaviors. These tested and validated programs are directed toward skill development in specific areas such as effective questioning, classroom management, team teaching, and teaching specific innovative programs. Teachers usually working in pairs use the minicourses at the school site and require a minimum of released time from classes.

The overall inservice training program should not be restricted in content to a specific science program, but should provide teachers with a better overall involvement in teaching. At all levels it should provide information on the new teaching methods of inquiry and discovery and the processes of science as used in the various innovative science courses. It might also provide information pertinent to the psychological aspects of learning and the practical applications of findings such as regarding the use of divergent versus convergent questioning. The inservice program should include a broad overview of the K-12 science program as it exists in the district and its articulation with the mathematics and social studies programs. With this knowledge the adaptations which science teachers make in their courses are more likely to lead toward better articulation with other courses in the school program.

The requirements for an inservice program vary in some aspects from the elementary level to the secondary level. A high school science teacher may see about 100 to 150 students a day, while the elementary teacher may see only 20 to 35 but carry responsibility for these students' entire curriculum. The number of teachers to be involved in an elementary science inservice program are therefore much greater than for the secondary science program.

In addition, sixty to eighty percent of the high school teachers have either a major and/or minor in a science area in contrast to almost none among the elementary school teachers. Therefore, science subject matter inservice programs at the high school level must only update knowledge of the teachers or augment the knowledge in one science field with additional information in another. However, more subject matter information must be provided for an elementary teacher, although not necessarily in depth in any single science area.

Another difference in elementary and secondary science inservice programs relates to facilities. Secondary schools usually provide classrooms equipped with laboratory facilities while elementary schools seldom do. Elementary inservice education therefore must also include specific information to help the teacher learn ways to convert her regular classroom into a laboratory during science class, ways to store equipment in current use, and how to minimize possible dangers inherent in using certain chemicals or equipment.

Another problem in planning for appropriate inservice education is in finding adequate staff for the inservice class. In many schools and districts the science teachers involved in implementing a new program may themselves make plans to gather regularly to discuss problems, to dry-run experiments, and to ask advice of a teacher who has taught the course before or is currently a week or so ahead of them. Sometimes this "master" teacher has taken a National Science Foundation or other sponsored institute on the particular course, but more often he is simply the teacher who first experimented with the course in the school or district. Administrators could make greater use of these teachers as consultants in their inservice programs, as well as bring in qualified people from outside the district. To facilitate this, the Laboratory has compiled a Personnel Resource File listing experienced and well-trained teachers of new science curricula in various counties of northern California and Nevada. Information in this file is available through the Laboratory Reference Room.

Providing for Continuing Evaluation and Curriculum Revision

Innovation in curriculum was usually the result of the interest of one or two faculty members experimenting with a single course or course sequence on their own. Their subjective opinions of student involvement and learning during the experimental period and of their own reactions to adaptations and improvisions usually constituted their "evaluation."

No district-wide evaluation procedures to assess the values of a given program were found, although several teachers and administrators offered suggestions for such a program. In individual schools some departments had designed lists of specific behaviors they felt students taking the accepted sequence of science courses should demonstrate at the end. A few teachers (usually studying for advanced degrees) were involved in actually trying to measure statistically the evidence for such behaviors in the students. Generally, however, teachers suggested that measurement of behavioral objectives should not be the only standard of evaluation. They supported the idea of district evaluation efforts which would also include a review of classroom dynamics as they relate to the learning process, a survey of teacher reactions to the curriculum, and an assessment, both quantitative and qualitative of the student's interests, attitudes, and reactions. It is only when such evaluation takes place continually, that a district can realistically assess the relative importance of science in the curriculum. This includes its relation to other subjects being taught and the need for changes in the teacher inservice program or in the science curriculum itself.

Because curriculum planning is a constant process, continuing evaluation and revision are needed. This need is especially apparent in regard to the inservice education program. Beginning teachers need help in adjusting to the existing curriculum, innovative teachers need specialized help with their new curriculum, and older teachers constantly need updating. The teaching staff in most schools is in a steady state with a whole spectrum of teachers; from those who have never before taught through those who are retiring.

The total school curriculum is affected when a new science curriculum is adopted. As the elementary program is changed, students need a different kind of course at the high school level to maintain and enhance the benefits from the innovation and insure smooth articulation. As the percentage of the school population completing high school continues to rise, the science program must change and become more flexible at the higher levels to accommodate new groups of students. Thus curriculum action must be dynamic in order to maintain vitality in the educational institution.

Recommended Instructional Practices

The last section of this summary deals with largely classroom practices which have been found to be instrumental in enhancing success in the implementation of new science curricula. These practices have been developed by teachers and administrators in order to cope with specific kinds of implementation problems. The major school level problems which surfaced during this study and examples of observed practices which appeared to be effective in alleviating these problems have been compiled into the summary that follows. Although detailed, this summary is not intended to be exhaustive, but is presented in the hope of stimulating creative problem solving on the part of readers. It is in this vein that this report is concluded.

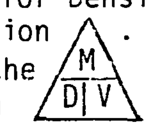
SUMMARY OF TEACHER AND ADMINISTRATIVE ADAPTIONS

Area of Description of Concern		Teacher or Administrator Practice
1. Math background of students is too low.	--	Teachers use materials from new elementary or junior high curricula, such as SCIS, AAAS, ESS, and ISCS projects.*
Graphing and Functional Relationships. Students lack knowledge of how to use graphs: to show function relationships, to extrapolate from given data, to predict most and least probable alternatives.		Teachers use materials originally developed for slow learners, such as BSCS Patterns and Processes (Special Materials).
		Teachers devise simple reproducible laboratory experiments utilizing relationships known or obvious to student to help him learn to express relationships graphically and to read graphs, e.g., Hooke's law--chemical solutions, temperature.
Students lack ability to organize data being collected so that it may be graphed; students lack ability to organize graph, to scale variables, etc. in order to portray data.	--	Teachers devise simple reproducible laboratory experiments to provide sufficient quick experiences in collecting data in organized manner.
		Teachers devise a series of graphing lessons and forms designed to teach graphing as a skill through classroom discussion sessions.

*SCIS--Science Curriculum Improvement Study.
AAAS--Association for the Advancement of Science Project. Science: A Process Approach.
ESS--Elementary Science Study.
ISCS--Intermediate Science Curriculum.

SUMMARY OF TEACHER AND ADMINISTRATIVE ADAPTIONS (Cont.)

Mathematical Formulas and Functions

Students lack knowledge of simple mathematical formula for calculating areas, volumes; of arithmetic operation used in computing the value for a variable.	--	Teachers devise a series of concrete lessons in measuring simple objects where the relationships involved are directly measured, e.g., tracing a figure on graph paper then actually counting the squares to find the area.
		Teachers devise alternate formulations of formulas to aid students, e.g., for Density-m/v, students may use the representation  . By covering up the unknown variable, the arithmetical operation to be performed on the known variables is visually obvious.

2. Reading level of students is too low.

Students cannot read specific material well enough to comprehend content and follow instructions.	--	Teachers devise a series of lessons starting with simple instructions to teach students this skill. The series is usually associated with graphing, or experimentation.
		Teachers modify instructions in test or manual, or prepare or adapt additional reading materials in the subject area, or these materials are written more simply and more redundantly.
		Teachers orally read all pertinent material to students and encourage class discussion until this skill is more fully developed.
Students' general reading comprehension is poor.	--	Teachers read and simply outline all essential material.

SUMMARY OF TEACHER AND ADMINISTRATIVE ADAPTIONS (Cont.)

		Teachers find lower level reading material from elementary or junior high curricula on the subject.
		Teachers try to devise ways of making all the learning as concrete as possible.
3. Problem solving skills of students are too low.		
Students' inquiry skills need development.	--	Teachers use materials developed for teaching these skills, e.g., SRA Inquiry Development, BSCS problem-presenting film loops.
Students' willingness to creatively "play around" with a problem is lacking.		Teachers present their own "discrepant events."
		Teachers refuse to answer students' questions as to the "right" answer or procedure, shifting the problem back to students.
		Teachers use divergent questions and encourage student to student interactions.
4. There is a wide range of students' science ability and interest:		
Special needs of advanced groups; Special needs of slower groups; Special needs of "humanities"; Students vs. "science" students; Special needs of students with poor attendance.	--	District encourages special student seminars or advanced placement groups.
		District encourages interdisciplinary student seminars or placement groups.
		District develops special science programs of varying dependence upon student science interest or ability.

SUMMARY OF TEACHER AND ADMINISTRATIVE ADAPTIONS (Cont.)

		District provides supplementary material for faster or slower students or those of diverse interests.
		Administration provides for a science-mathematics laboratory (or study hall) staffed each period by a knowledgeable teacher. Students can go for help or for additional laboratory periods.
		Districts provide a different sequence of courses for different student groups.
		Teachers incorporate vocational information of students' interest into the science course.
		Teachers incorporate projects of interest to humanities students into the science course.
		Teachers pair students in laboratory to provide tutoring for slower students or to minimize the negative effects of excessive absences.
		Teachers use laboratory experiences as the foundation of the course, adding outside reading, projects, end-of-chapter problems, etc., to enrich the program and provide more challenge to faster students.
5. Teachers lack the ability to teach the new laboratory-oriented curricula.		
Teachers lack up-to-date background in the subject area, e.g., for teaching a particular new course.	--	District encourages development of joint district-college courses in specific subject areas and teaching methods.

SUMMARY OF TEACHER AND ADMINISTRATIVE ADAPTIONS (Cont.)

Teachers lack special skills required in utilizing new teaching methods such as inquiry and discovery.	District develops its own inservice program using qualified teachers in the district, or utilizes research and development self-instructional products such as minicourses.*
	District adopts class scheduling which allows teachers opportunities to get together informally to solve these problems, e.g., once a week an "assembly" schedule is followed. Students are dismissed early in order to give all teachers a chance to work together according to their department or to attend inservice programs.
	Sabbatical leaves are provided for teachers to undertake long-term study.
6. In-school preparation time is too short.	
Teachers lack time to adequately prepare for new laboratory oriented courses. --	Preparation load is shared between teachers of the same course.
	Storage of supplies is reorganized with respect to the course rather than alphabetically.
	Student or other assistants are provided.
	Administration reduces the class load for the teacher of a new innovative course.
	The administration schedules teacher-preparation periods together in order to give the teacher

*Teacher education packages designed for developing specific classroom skills. These courses are based upon microteaching and developed at Far West Laboratory for Educational Research and Development.

		a longer block of time in which to "trouble shoot."
		The administration schedules teacher-preparation periods at the beginning or end of the day so that teachers may more easily extend "trouble-shooting" time as desired.
7. Insufficient class time is scheduled.		
Students lack sufficient time to complete laboratory experiments.	--	Flexible schedule allows a longer block of time once a week or even more often.
Post laboratory class discussion time is inadequate.		By dropping one period each day, other periods can be extended.
		Laboratory assistants are provided to preset-up equipment in order to reduce laboratory manipulative problems and save time during laboratory periods.
8. New programs do not articulate well with existing ones.		
Lower level courses do not provide prerequisites, higher level courses repeat or do not build upon learnings. College board or other exams do not reflect the learnings of new courses.	--	Inservice teacher institutes treat specific common problems of articulation.
		Inservice institutes anticipate problems of articulation of new course with upper level courses and direct effort toward their solutions, or train teachers in advance to change the upper level course.
		The counseling department is kept informed of changes in department courses and accepted sequences and prerequisites.

District sets-up teacher manned committees to plan course sequence changes.

The counseling department is prepared to justify scores on placement exams to colleges in terms of the curriculum offered.

Administration, teachers, and others petition college placement examining board to make new tests which reflect new learnings.

APPENDICES

APPENDICES

A. Description of New Science Curricula and Course Improvement Materials

B. Principal's Questionnaire on Science Education

C. Teacher's Questionnaire on Science Education

D. Distribution of School Districts Using Intermediate New Science Curricula

E. Distribution of School Districts Using BSCS First Year Biology Curricula

F. Distribution of School Districts Using Advanced New Science Curricula

G. Guide to Classroom Observation--Teacher Behavior

H. Guide to Classroom Observation--Student Behavior

I. Teacher Interview Questions

J. Student Interview Questions

APPENDIX A

DESCRIPTION OF NEW SCIENCE CURRICULA AND COURSE IMPROVEMENT MATERIALS

Project Title, Director and Address	Grade Level	Description	Teacher Education Opportunities
COURSE DEVELOPMENT PROJECT IN QUANTITATIVE PHYSICAL SCIENCE (QPS) Dr. Sherwood Githens, Jr. Department of Education Duke University/College Station Durham, North Carolina 27708	9	Provides guidance to administrators and teachers in teaching physical science through guided experiences.	Self-explanatory teacher-manual; inservice training not required.
EARTH SCIENCE CURRICULUM PROJECT (ESCP) Dr. Joseph L. Weitz P. O. Box 1559 Boulder, Colorado 80302	8	Laboratory oriented earth science develops tools that facilitate inquiry; concepts covered include materials of our planet, solar system, universe, space and time, and adaptations to environment.	Inservice course each semester at University of Colorado; summer institutes; consultants available.
ELEMENTARY-SCHOOL SCIENCE PROJECT (ASTRONOMY)-ESSP Dr. J. Myron Atkin College of Education University of Illinois Urbana, Illinois 61801	5-9	Based on astronomy and provides for laboratory investigations, use of programmed materials, independent study, and discussion groups. Progress report available free from Director.	Consultants through Harper and Row in the future.
INQUIRY DEVELOPMENT PROGRAM (IDP) Contact: Science Research Associates/Chicago, Illinois Dr. Richard Suchman Berkeley, California	6-8	Six to eight week course using scientific problems to teach children science; utilizes short topic inquiry films, etc.	Obtain information from contact personnel.

Project Title, Director and Address	Grade Level	Description	Teacher Education Opportunities
INTERACTION BETWEEN MATTER AND ENERGY (IME) Contact: Norman Abraham, or Patrick Blach, Yuba City H.S., Yuba City, California Donald Chaney, Los Gatos, California; or Rohr Baugh, Professor of Botany, Univ. of Oklahoma, Norman, Oklahoma	9	Physical science program based on inquiry system of teaching and learning through observation, investigations, literature research, etc.	Obtain information from contact personnel.
INTERMEDIATE SCIENCE CURRICULUM (ISCS) Dr. Ernest Burkman Kellum Hall Basement Florida State University Tallahassee, Florida 32306	7-9	Contains materials designed for above to below average students; uses computer assisted instruction as tool for evaluation.	Inservice Teacher training; preschool conference.
INTRODUCTORY PHYSICAL SCIENCE (IPS) Dr. Uri Haber-Schaim Education Development Center 55 Chapel Street Newton, Massachusetts 02160	8, 9, 10	Introductory study of matter by series of laboratory investigations eventually building an atomic model; terminal course for some as well as providing a foundation for further work in the sciences.	Provides for setting up workshops; and workshops instructors' inservice.

Project Title, Director and Address	Grade Level	Description	Teacher Education Opportunities
MICHIGAN SCIENCE CURRICULUM COMMITTEE JUNIOR HIGH SCHOOL PROJECT (MSCC-JHSP) Dr. W. C. Van Deventer Department of Biology Western Michigan University Kalamazoo, Michigan 49001	6-8	Interdisciplinary approach to the study of general science, thirteen units consisting of 55 laboratory experiences already developed, several materials available free.	Correspondence only for teachers outside Michigan.
SECONDARY SCHOOL SCIENCE PROJECT (SSSP); TIME, SPACE, MATTER (TSM) Dr. George J. Pallrand 10 Seminary Place The State University, Rutgers New Brunswick, New Jersey 08903	8-10	Students learn principles of scientific inquiry through a sequence of nine interrelated investigations by using principles of chemistry, physics, geology, astronomy, and mathematics	McGraw-Hill provides traveling consultants for inservice institutes; extension courses at some colleges.
SPECIAL MATERIALS SCIENCE PROJECT (SMSP) John J. Rizza Sunrise Drive RFD #4 Mahopac, New York 10541	6-8	Science and mathematics program for "slow learners."	Consultants available for teachers; project director for teacher groups.

Project Title, Director and Address	Grade Level	Description	Teacher Education Opportunities
BIOLOGICAL SCIENCES CURRICULUM STUDY (BSCS) Dr. William V. Mayer University of Colorado P. O. Box 930 Boulder, Colorado 80302	10	Laboratory-oriented courses (Blue, Green, Yellow) designed for tenth grade students based on molecular, ecological, and cellular approaches.	Area consultants listed in newsletter: college-school inservice training, summer and academic-year institutes, publications.
	10,11, 12	Course (Patterns and Processes) designed for the "slow learner."	
	12	Second course (Interaction of Experiments and Ideas) designed for above average, college bound students.	
CHEMICAL BOND APPROACH PROJECT (CBA) Dr. Laurence E. Strong Earlham College Richmond, Indiana 47375	11,12	Central approach is the making and breaking of ties between atoms (chemical bonds). Effort made to distinguish between data produced by experimentation and ideas used for interpretation.	Summer Institutes.
CHEMICAL EDUCATION MATERIAL STUDY (CHEM Study) Dr. George C. Pimentel University of California Berkeley, California 94720	11,12	Open-ended experimentation with careful laboratory observations representing combined judgment of scholars and teachers on a beginning course in chemistry covering major concepts.	Teacher training films; consultants available; NSF institutes
HARVARD PROJECT PHYSICS (HPP) Dr. F. James Rutherford Pierce Hall-G2 Cambridge, Massachusetts 02138	11,12	Broad, humanistic presentation of physics concepts by independent study, laboratory investigations, seminars, computer assistance, multimedia system approach.	NSF inservice training; academic year institutes; cooperative college school science program; possibly consultants for 1969-70.

Project Title, Director and Address	Grade Level	Description	Teacher Education Opportunities
PHYSICAL SCIENCE STUDY COMMITTEE PHYSICS (PSSC) Contact: Miss G. Kline Education Development Center 55 Chapel Street Newton, Massachusetts 02160	11	Designed to explore indepth structure of physics by concentration on fewer concepts. Students discover and verify physical knowledge through well-planned laboratory experiments.	Obtain information from Education Development Center
PORTLAND PROJECT-INTEGRATION OF CHEMISTRY & PHYSICS FOR SECONDARY SCHOOLS Contact: Dr. Michael Fiasca Portland State College P. O. Box 751 Portland, Oregon 97207	11-12 or 10-11	Provides for an integration of CHEM Study, or CBA and physics (PSSC). BSCS has now been brought into the integration.	Teacher guides for CHEM Study-PSSC and CBA-PSSC integration.
RADIOISOTOPES & INQUIRY J. L. Rips Bio-Atomic Research Foundation 12020 Chandler Blvd. North Hollywood, Calif.	10-12	Utilizes radioisotopes and radioisotopic techniques as investigative tools in laboratory.	Consultants available for inservice teacher training.

77/78

APPENDIX B

FAR WEST LABORATORY
FOR EDUCATIONAL RESEARCH AND DEVELOPMENT
1 Garden Circle, Hotel Claremont
Berkeley, California

PRINCIPAL'S QUESTIONNAIRE ON SCIENCE EDUCATION

The Far West Laboratory for Educational Research and Development is undertaking a program designed to provide school personnel in Northern California and Nevada with information and products to assist teachers in implementing innovations in their science instruction. Your answers to the following questions will help us to obtain an estimate of the status of the use of new science curricula in our region.

Please complete each item to the best of your ability and return this form to us using the enclosed envelope. Your answers will be regarded by us as confidential and used for purposes of research and planning only.

Personal and School Data

1.___

Your name____

Name and Location of School______________________ 2.___

If you are teaching, what subjects do you teach? 3.___

Subjects____ 4.___

The following information is needed to classify your school. 5.___

6.___

Do any of these special groups constitute more than 20% of the student body? Check each alternative that applies.

☐ Negro ☐ Mexican American ☐ Children of Migrant Agricultural Workers ☐ American Indian ☐ None of these 7.___

What type of area is the largest source of the student population? Check the one alternative that provides the largest fraction of the student population.

☐ Rural ☐ Small city-town ☐ Suburban ☐ Urban ☐ Large urban 8.___

How would you describe the socio-economic background of the majority of the student population? Check one alternative.

☐ Lower income ☐ Lower middle income ☐ Upper middle income ☐ Upper income 9.___

Does your school provide for tracking (ability or homogeneous grouping) of students?

☐ Yes ☐ No 10.___

What are your school's minimum science requirements for graduation? Check one.

☐ One year general science (no laboratory requirement)

☐ One year biological or physical science (no laboratory requirement) 11.___

☐ One year general science (laboratory requirement)

☐ One year biological or physical science (laboratory requirement)

☐ One semester biological science

☐ Two or more years of science

☐ One semester physical science

☐ No science requirement

FOR OFFICE USE

Science Program Data

12. How many members of your staff are teaching science classes?
☐ 1-0 ☐ 2-3 ☐ 4-6 ☐ 7-9 ☐ 10 or more

(a) Check each new science curriculum being tried or adopted at your school
(b) Give name of teachers using new curriculum.
(c) Indicate years of experience teacher has had in using new curriculum

Item	Science Course	Name of New Science Curriculum Check each one that applies	Name of Teacher	Years Experience in Teaching New Science Curriculum
13. 14.	General Science	☐ ESCP-Earth Science Curriculum Project ☐ SSSP-Time, Space, and Matter (Princeton Proj.) ☐ IPS-Introductory Physical Science ☐ ESSP-Illinois (Astronomy) ☐ MSCC-JHSP-Michigan Science Curriculum Comm. ☐ SRA-Inquiry Approach ☐ IME-Interaction of Matter and Energy		
15. 16.	Biology	☐ Radioisotopes and Inquiry BSCS-Biological Science Curriculum Study Versions ☐ Blue Version ☐ Green Version ☐ Yellow Version ☐ Patterns and Processes (Special Materials) ☐ Interaction of Experiments and Ideas		
17. 18.	Chemistry	☐ CHEMS-Chemical Education Materials Study ☐ CBA-Chemical Bond Approach		
19. 20.	Physics	☐ PSSC-Physical Science Study Committee ☐ PSSC-Advanced Topics ☐ HPP-Harvard Project Physics ☐ ECCP-Engineering Concepts Curriculum Project ☐ NSTA-NASA Aerospace Science Education Project ☐ NASA-Aerospace Resource Guide		
21. 22.	Other Science Courses	☐ Portland Project (Integration of Chemistry and Physics) ☐ Others: ______		

Please indicate the past and future status of your school with respect to the use of new science curricula.
Write the name of each science curriculum in which your staff has demonstrated interest in recent years and place a check in the appropriate column.

Item	Title of Curriculum	It was considered but not tried	It is now being considered for use	It was tried and abandoned
23.				
24.				
25.				

Would your school be interested in testing new science curriculum material in the future if smooth transition and articulation with other courses could be worked out? ☐ Yes ☐ No ☐ Remarks________________ 26.__

____

____

Indicate the subject area in which members of your staff participated in curriculum revision projects in the last 10 years. 27.__

☐ Science ☐ Math ☐ None

For approximately what period of time did they participate? 28.__

☐ Less than 1 year ☐ 1 to 3 years ☐ Over three years

Teacher Inservice Science Education Data

Indicate the opportunities for teacher inservice science education provided by your district. 29.__ 30.__

	Average number of days		
	1-5	6-10	Over 10
☐ None			
☐ During the school year			
☐ During school year vacation			
☐ During summer vacation			
☐ At other times (specify)			

What other opportunities for inservice teacher education in science are available within commuting distance of your school? Check each item that applies. 31.__

- ☐ Junior college
- ☐ College level extension course
- ☐ County-sponsored teacher conferences
- ☐ Regional conferences of professional organizations
- ☐ NSF Institutes
- ☐ Other institutes
- ☐ Other (specify)

In your opinion what are the inservice science education needs of your teaching staff? Check each item that applies. 32.__

- ☐ Subject matter
- ☐ Teaching techniques
- ☐ Knowledge about new science curricula
- ☐ Preparation for teaching a specific new science curriculum
- ☐ Other (specify)

In view of your experience and knowledge relative to the development of science curricula in the past decade, what, in your opinion, are the most crucial problems still evident? 33.__

____

____

____

____

____

APPENDIX C

FAR WEST LABORATORY
FOR EDUCATIONAL RESEARCH AND DEVELOPMENT
1 Garden Circle, Hotel Claremont
Berkeley, California

TEACHER'S QUESTIONNAIRE ON SCIENCE EDUCATION

The Far West Laboratory for Educational Research and Development is undertaking a program designed to provide school personnel in Northern California and Nevada with information and products to assist teachers in implementing innovations in their science instruction. Your answers to the following questions will help us to obtain accurate data on the problems teachers in our region encounter in adopting science teaching innovations in their schools.

We will distinguish between teachers who use innovative material for the first time, and those who have had an opportunity to re-teach the program. First time users are often aware of problems which may become less remarkable to them as they gain experience in handling the innovation. Teachers re-using the innovative material may become more aware of subtle problems which were not obvious to them when they first used the materials.

Please complete each item to the best of your ability and return this form to us using the enclosed envelope. Your answers will be regarded by us as confidential and used for purposes of research and planning only. 1.___

Your name________________________ 2.___
Name and Location of School________________________ 3.___

Which new science curriculum or innovation are you currently using in teaching your science classes? (E.g. IPS, CHEMS, PSSC, HPP, ESCP-Earth Science, SRA Inquiry, BSCS version, etc.)________________________ Grade______________ 4.___ 5.___ 6.___

If you teach more than one new science curriculum, please answer for each one on a separate questionnaire.

Indicate your experience with this specific innovative material. 7.___

- ☐ Less than one semester
- ☐ One semester to one year
- ☐ Over one year to two years
- ☐ Over two years to five years
- ☐ Over five years

How did you first learn about this curriculum? Check one item that best applies. 8.___

- ☐ University or college course
- ☐ Literature from professional organization (e.g., CTA, NSTA)
- ☐ NSF Institute
- ☐ Other meetings or conferences
- ☐ Science coordinator
- ☐ Another teacher
- ☐ Television, newspaper or other public medium
- ☐ Literature from book publisher
- ☐ Other (specify)________________________

What special preparation have you had for teaching this curriculum? 9.___ 10.___

- ☐ Attended curriculum workshop (up to 10 class hours)
- Attended curriculum institute (over 10 class hours)
  - ☐ Sponsored by NSF
  - ☐ Otherwise sponsored
- ☐ None
- ☐ Other________________________

At which grade level is this course usually taught in your school.

☐ 7th ☐ 8th ☐ 9th ☐ 10th ☐ 11th ☐ 12th 11.___

FOR OFFICE USE

Indicate the seriousness of the problems listed below according to your experience in using this curriculum in your school. Check one box for each item.

After you have checked all items to indicate your reaction, please place a check in the 4th column for the five items you think present the most serious problems for most teachers.

		Minor or no problems	Moderately serious problems	Very serious problems	Most serious problems to most teachers
	Preparation of Students				
12.___	1. Math background of most students is too low.				
13.___	2. Reading level of most students is too low.				
14.___	3. Generally, the students lack an adequate basic knowledge of science.				
15.___	4. Most students lack sufficient skills in using scientific methods of problem solving.				
16.___	5. Generally, students are not sufficiently adept at handling laboratory apparatus.				
17.___	6. Most students have had inadequate elementary or junior high school science courses.				
18.___	7. Others______________________________				
	Suitability of Curriculum in Your School				
19.___	8. Often these materials don't provide for adequate development of basic concepts.				
20.___	9. The sequence of presentation of material in the text is poor				
21.___	10. The laboratory and text are not well correlated.				
22.___	11. The curriculum does not fit well into the science sequence.				
23.___	12. The curriculum materials are not suitable for my students, generally.				
24.___	13. The required materials are too expensive.				
25.___	14. Other ______________________				
	School Plant or Organization.				
26.___	15. Laboratory space or furniture is inadequate for desired student experimentation.				
27.___	16. Laboratory equipment or material is inadequate for sufficient student experimentation.				
28.___	17. School scheduling does not permit a sufficient block of time for science classes.				
29.___	18. Insufficient time is provided for science teachers to plan and prepare for laboratory.				
30.___	19. Other______________________________				

In your opinion what preparation or assistance do most teachers need in order to effectively teach this curriculum? Please rank 1 to 5 giving the most important item the number 1 and the least important the number 5.

31.___ ☐ I think most teachers need special instruction to teach this curriculum.
32.___ ☐ I believe teachers need to see this curriculum taught.
33.___ ☐ I think most teachers need extra time or opportunity to work out lessons when introducing this new curriculum into the school.
34.___ ☐ I believe teachers need help from consultants in introducing this curriculum into the school.
35.___ ☐ I think most teachers need an especially strong subject area background.
36.___ Other______________________________

To what extent do you use the materials specially designed for this curriculum? Check each item in the appropriate column.

	All or most of the material	A few selected portions	None	
Textbook				37.__
Laboratory exercises				38.__
Laboratory equipment				39.__
Films				40.__
Tests				41.__
Special topic reading materials				42.__
Programmed materials				43.__
Teacher's manual				44.__
Other (specify)				45.__

Check the ways in which you have added to or changed this curriculum for your class or school. Double check to indicate materials which you personally designed or developed.

☐ No changes made
☐ Laboratory experiments
☐ Laboratory equipment
☐ Supplementary text
☐ Reading materials
☐ Materials on local environment

☐ Lessons from another curriculum (give title of text or other curriculum)
____
____
☐ Films and other visual aids
☐ Others (specify)______________
____

46.__ 47.__ 48.__ 49.__ 50.__ 51.__ 52.__ 53.__ 54.__

What first hand data on the effectiveness of this curriculum in your school is accessible to you? Check each appropriate item.

☐ None
☐ I don't have sufficient information to answer
☐ Students' standardized achievement test results
☐ Other standardized test results on students
☐ Comparison of students' performances before and after taking course

☐ Comparison of students' performances in this course vs. in the traditional course in same subject
☐ Follow-up studies of students who have taken this course
☐ Other studies (specify)_______
____
____

55.__ 56.__ 57.__ 58.__ 59.__ 60.__ 61.__ 62.__

Which of the following groups of students normally take this course in your school? Check each item that is appropriate.

☐ Above average ability
☐ Average ability
☐ Below average ability

☐ College oriented
☐ Vocationally oriented
☐ Underachievers
☐ Other (specify)____________

63.__ 64.__ 65.__ 66.__ 67.__ 68.__ 69.__

How do students respond to this new curriculum? Check a response for each student group that applies

Student Description	Favorably	Indifferently	Unfavorably	
Above average				70.__
Average				71.__
Below average				72.__
College oriented				73.__
Vocationally oriented				74.__
Underachievers				75.__
Other (specify)				76.__

TURN PAGE

What do you, as a science teacher, think are the special strengths of this curriculum?

77.
78.

What do you think are the special weaknesses of this curriculum?

79.
80.

What are your recommendations relative to the use of this curriculum?

81.
82.

In view of your experience and knowledge relative to the development of science curricula in the past decade, what, in your opinion, are the most crucial problems still evident?

83.
84.
85.

GPO 975-193

APPENDIX D

DISTRIBUTION OF SCHOOL DISTRICTS USING INTERMEDIATE NEW SCIENCE CURRICULA

*Number of Districts Reporting Use of New Curriculum Materials

	Curricula			Other Materials	
CALIFORNIA COUNTIES	ESCP	TSM	IPS	IDP	IME
Alameda	5		4	4	1
Butte	1		1		
Calaveras				1	
Contra Costa	3	2	2	2	
El Dorado			2	1	
Fresno	1		7		1
Glenn			1		
Lake			1		
Marin			1		
Merced				1	
Monterey	1		2	1	
Napa			1		
Placer	1		1		
Plumas	1				
Sacramento	2		1	1	
San Francisco	1				
San Joaquin	2		1		
San Mateo	2	4	1	1	3
Santa Clara	7	3	4	3	3
Santa Cruz			1	2	
Siskiyou	1	1	1		
Solano	1	1	2	1	
Sonoma	1		2		
Stanislaus			3	1	
Sutter	2		1		1
Tehama	1				
Tulare	1		3		
Tuolomne				1	
Yolo			1	1	
Number of California Districts	34	11	44	21	9
NEVADA COUNTIES					
Elko			1		
Humboldt	1	1	1		
Lincoln	1				
Nye	1				
Washoe	1			1	
White Pine	1			1	
Total Number of California and Nevada Districts	39	12	46	23	9

*Based upon questionnaire returns only. The number of districts may refer to single school or district-wide adoption of the specific curriculum.

APPENDIX E

DISTRIBUTION OF SCHOOL DISTRICTS USING BSCS FIRST YEAR BIOLOGY CURRICULA

CALIFORNIA COUNTIES	*Number of Districts Reporting Use of BSCS Versions			
	Blue	Green	Yellow	Special Materials
Alameda	5	8	5	3
Amador	1	1		
Butte	2		2	
Calaveras	1			
Contra Costa	4	5	6	5
Del Norte		1		
El Dorado	1	2	1	
Fresno	4	3	4	1
Glenn			1	
Humboldt		1		
Lake		3		
Madera			2	
Marin	1	2	2	
Mendocino		1	1	1
Merced	2	1		
Modoc		1		
Monterey	3	2		
Napa		1	2	
Nevada		1		1
Placer	2	1	1	1
Plumas	1	1		
Sacramento	4	2	3	5
San Benito			1	
San Francisco	1	1	1	
San Joaquin	2	2	2	
San Mateo	4	1	4	4
Santa Clara	7	4	1	4
Santa Cruz	1	2		
Siskiyou	1	1		
Solano	3	4	2	2
Sonoma	3	4	2	1
Stanislaus	4			2
Sutter	2	1	1	1
Tehama	1			
Tulare		2	5	1
Tuolumne			1	
Yolo			2	1
Yuba	1			1
Number of Calif. Districts	61	59	51	34

*Based upon questionnaire returns only. The number of districts may refer to single school or district-wide adoption of the specific curriculum.

APPENDIX E (Continued)

DISTRIBUTION OF SCHOOL DISTRICTS USING BSCS FIRST YEAR BIOLOGY CURRICULA

NEVADA COUNTIES	Blue	Green	Yellow	Special Materials
Douglas			1	
Elko			1	
Humboldt	1			
Lincoln		1		
Washoe			1	
White Pine		1		
Number of Nevada Districts	1	2	3	0
Total number of California and Nevada Districts	62	61	54	34

APPENDIX F

DISTRIBUTION OF SCHOOL DISTRICTS USING ADVANCED NEW SCIENCE CURRICULA

CALIFORNIA COUNTIES	Number of Districts Reporting Use of New Curriculum Materials* CHEM Study	PSSC	Biology
Alameda	11	9	2
Amador	3	3	
Butte	1	1	
Calaveras		1	
Contra Costa	7	7	1
El Dorado	2	2	2
Fresno	8	8	
Glenn	1	1	
Humboldt	1		
Lake	2	2	
Lassen	1		
Madera	1	1	
Marin	3	2	1
Mendocino	2	2	1
Monterey	3	3	4
Napa	1	1	
Nevada		1	
Placer	2	2	
Plumas	1	1	
Sacramento	6	4	1
San Benito	1	1	
San Francisco	1	1	
San Joaquin	4	3	
San Mateo	4	3	
Santa Clara	9	9	1
Santa Cruz	3	3	
Solano	5	6	1
Sonoma	3	6	1
Stanislaus	4	3	2
Sutter	2	1	
Tulare	4	7	
Tuolumne	1	1	
Yolo	3	3	
Yuba		1	
Number of Calif. Dists.	100	99	17

NEVADA COUNTIES

Douglas	1		
Elko		1	1
Humboldt		1	
Lincoln	1	1	
Washoe	1	1	
Number of Nevada Dists.	3	4	1
Total number of Calif. & Nevada Districts	103	103	18

*The number of districts may refer to single schools or district-wide adoption of the specific curriculum.

APPENDIX G
GUIDE TO CLASSROOM OBSERVATION--TEACHER BEHAVIOR

IDEAL TEACHER BEHAVIOR	EVIDENCE (Behavioral Cues, Visible Products)	SOURCE OF EVIDENCE		
		Sessions		Other
		Lab	Disc.	
KNOWLEDGE. Teacher indicates familiarity with subject matter	Where appropriate:			
	1a. T uses historical vignettes		D	Lecture
	1b. T uses new analogies to help students understand concepts		D	Lecture
	1c. T uses extra demonstrations to put over concept	L		Lecture
	1d. T makes up or offers extra problem or worksheets for student use when needed			T files
	1e. T points out common applications of concepts	L	D	Lecture
Teacher indicates familiarity with Laboratory	2a. T adapts or revises laboratory experiments only as appropriate	L		T files
	2b. T appears knowledgeable about laboratory equipment (as evidenced by answers to students' questions, making repairs, etc.)	L	D	
	2c. T has laboratory apparatus readily available to students for "idea testing"	L		
Teacher displays familiarity with this specific science curriculum	3a. T refers students to other parts of text or other sources treating the same subject differently or in more detail	L	D	Lecture
	3b. T uses supplementary materials designed for course	L		Lecture
	3c. T emphasizes those ideas in the current unit which are	L	D	Lecture
	3d. T uses the laboratory experiments which are most useful in developing the current unit	L	D	

APPENDIX G

GUIDE TO CLASSROOM OBSERVATION--TEACHER BEHAVIOR (Cont.)

IDEAL TEACHER BEHAVIOR	EVIDENCE (Behavioral Cues, Visible Products)	SOURCE OF EVIDENCE Sessions Lab	Disc.	Other
ROLE ASSUMPTION Teacher displays knowledge of T role as required by this curriculum	4a. T provides learning activities designed for S growth	L	D	Lecture
	4b. T provides learning activities designed for concept understanding	L	D	
	4c. Discussion revolves around Ss questions		D	
	4d. Discussions encompass inquiry-like sessions		D	
	4e. T serves as a resource person, rather than as an authority	L	D	
	4f. T function as a presenter or identifier of problems rather than as the resolver	L	D	Lecture
SKILLS ATTAINMENT Teacher indicates knowledge of teaching methods, of science instruction	5a. T uses inquiry skills, asks open-ended questions of students		D	
	5b. T teaches problem solving skills	L	D	
	5c. T utilize Ss laboratory experiences skillfully in developing concepts		D	
	5d. T appropriately uses demonstrations		D	Lecture
	5e. T appropriately uses audiovisual materials		D	Lecture
	5f. T uses lecture skillfully (and sparingly)			Lecture
	5g. T conducts discussions with ample student participation		D	

APPENDIX G

GUIDE TO CLASSROOM OBSERVATION--TEACHER BEHAVIOR (Cont.)

IDEAL TEACHER BEHAVIOR	EVIDENCE (Behavioral Cues, Visible Products	SOURCE OF EVIDENCE		
		Sessions		Other
		Lab	Disc.	
READINESS, INTENT PURPOSE Teacher indicates understanding of philosophy of this course	6a. T says he likes the course			Interview
	6b. T brings in supplementary materials to highlight purposes of course	L	D	Lecture
	6c. T is proud of his students' involvement	L	D	Interview
	6d. T is proud of his students' accomplishments, progress	L	D	Interview
	6e. T maintains interest despite poor facilities, lack of adequate funding or time	L		Interview
	6f. T uses a grading system consistent with course intent			T record book interview
FOCUS OF CLASSROOM T provides evidence of meaningful major over all concerns and foci in teaching	7a. T spends minimal time on administrative, organizational details	L	D	Lecture
	7b. T spends minimal time on procedural details	L	D	
	7c. T spends minimal time dealing with inappropriate behaviors of Ss	L	D	
	7d. T spends minimal time on classroom props (text, manuals etc.)	L	D	Lecture
	7e. T spends minimal time on substance of curriculum	L	D	Lecture
	7f. Classroom time is spent in activities which revolve around S rather than T	L	D	
	7g. Learning activities are designed for skill attainment	L	D	Lecture
	7h. Learning activities are designed for conceptual growth	L	D	Lecture
	7i. Learning activities are designed for content development	L	D	Lecture
	7j. Learning activities are designed for student growth	L	D	Lecture

APPENDIX H

GUIDE TO CLASSROOM OBSERVATION--STUDENT BEHAVIOR

IDEAL STUDENT BEHAVIOR	EVIDENCE (Behavioral Cues, Visible Products)	SOURCE OF EVIDENCE: Sessions Lab.	Sessions Disc.	Other
KNOWLEDGE Ss indicates familiarity with subject matter	1a. Ss refer to specific relevant subject matter in class		D	
	1b. Evidence of students prior acceptable class performance is provided by Ss visible products such as reports, graphs, etc.			Rec. Bk. (T, S) Lab Report
	1c. Ss acceptable prior out-of-class performance on homework, etc., is evidenced by Ss visible products, such as reports, models, problem sets			Prob. sets, Reports, models
Ss indicate familiarity with a science laboratory	2a. Ss follow lab procedure knowledgeably	L		
	2b. Ss deviate slightly from a given lab procedure with confidence	L		
	2c. Ss ask advice, procedure from other students	L		
	2d. Acceptable prior in-class performance is evidenced by student products, such as lab manual			Records, etc.
UNDERSTANDING Ss indicate their grasp of basic concepts, ideas, in science	3a. Ss suggest alternative hypotheses, ideas		D	
	3b. Ss suggest alternative experimental designs, procedures	L	D	
	3c. Ss paraphrase a concept (e.g. "oh, that's like..." or "I see, it's like...")		D	
	3d. Ss extend an idea, apply it to other cases	L	D	
	3e. Ss evaluate ideas of others	L	D	
	3f. Ss interpret histograms or other group data		D	
	3g. Ss ask non procedural questions about concepts its implications, etc.		D	

APPENDIX H

GUIDE TO CLASSROOM BSERVATION--STUDENT BEHAVIOR (Cont.)

IDEAL STUDENT BEHAVIOR	EVIDENCE (Behavioral Cues, Visible Products)	SOURCE OF EVIDENCE: Sessions Lab	SOURCE OF EVIDENCE: Sessions Disc.	SOURCE OF EVIDENCE: Other
ROLE ASSUMPTION Ss indicate ability to act as active participant and critical observer	4a. Ss challenge teacher's ideas, solutions	L	D	
	4b. Ss challenge other student's ideas	L	D	
	4c. Ss record data and observations in retrievable form	L		Records
Ss indicate willingness to tolerate ambiguity, to work over extended period of time to obtain self-satisfying results	5a. Ss throw out wild ideas for consideration, extend wild ideas of others		D	
	5b. Ss recognize need for expenditure of effort or "work" involved in being scientific	L	D	Interview
	5c. Ss work carefully over a long period of time with few rewards toward an expected end	L		Model building outside report, Interview
	5d. Ss indicate they maintain interest in experiment despite delayed results	L	D	
SKILLS ATTAINMENT Ss indicate knowledge and development of scientific skills	INQUIRY SKILLS 6a. Ss demonstrate inquiry skills, ask relevant questions spontaneously	L	D	
	LAB SKILLS 6b. Ss make critical observations	L		
	6c. Ss measure accurately	L		
	6d. Ss record data legible and accurately	L		
	6e. Ss handle laboratory equipment adequately	L		
	6f. Ss estimate the order of magnitude accurately		D	
	6g. Ss take account of experimental error	L		Problems

APPENDIX H

GUIDE TO CLASSROOM OBSERVATION--STUDENT BEHAVIOR (Cont.)

IDEAL STUDENT BEHAVIOR	EVIDENCE (Behavior Cues, Visible Products)	SOURCE OF EVIDENCE Sessions Lab.	Disc.	Other
SKILLS ATTAINMENT Continued	ANALYTICAL SKILLS			
	6h. Ss use and understand graphing techniques for handling data	L	D	
	6i. Ss analyze, draw inferences from own or group data	L	D	
	6j. Ss generalize from data, construct models		D	
	6k. Ss design further experiments to elicit further data or refine procedures	L	D	
READINESS, INTENT PURPOSE Students indicate they are involved in, and like, the course	7a. Ss say they like the course			Interview
	7b. Ss constructively criticize features of the course (e.g. inadequacies of equipment, suggesting further progress they could make with improved facilities)	L		Interview
	7c. Ss bring in supplementary materials from home to improve the course	L	D	Interview
	7d. Ss do outside reading in this subject area		D	Interview
	7e. Ss demonstrate pride in their accomplishments ("Look what I made, that's our part of the graph'.)	L	D	Interview

APPENDIX I
TEACHER INTERVIEW QUESTIONS

School: ____________________ Class:__________ Period:__________
Grade: 7 8 9 10 11 12
Teacher: ____________________ S - Subgroup:__________

1. Date program introduced Fall Winter Spring Summer 62 63 64 65 66 67 68 By whom?__________

2. Date T first used program here__________ S-subgroup__________ Grade__________

3. Dates T taught program elsewhere__________ S-subgroup__________ Grade__________

4. In their present form, for what student groups are the course materials suitable?
   Ability: [] Above Average [] Average [] Below Average
   Achievement: [] High [] Medium [] Low
   Motivation: [] High [] Medium [] Low
   Orientation: [] College [] Vocational [] Other__________
   At what grade level should it be offered?__________

5. What courses, units should students master prior to this course to best benefit from it?

   Math__________

   Science__________

   To what extent did your students do so?__________

6. How do the S - skills gained in this course help Ss in their other courses/and vice versa?

7. How does this curriculum fit into the currently used science program here?

   Specifically how does this course relate to CHEMS, BSCS, PSSC?__________

8. What changes would you recommend in the overall school science program?

9. What special preparation did you have to teach this course?__________

10. What T skills or knowledge are needed to effectively teach this course?__________

1. What lessons are difficult to teach or beyond the level of your pupils? Nature of difficulty? How handled?

Difficult Lessons	Area of Difficulty Circle 2 highest ranks		Teacher Adaptation
	1-Math concepts 2-Arith. skill 3-Math appln to PS 4-Readg comprehesn 5-Gen read. skill 6-Readg habits 7-Identif of probl. 8-Relatg. data with concepts	9-PS process 10-Xs T work 11-Nd T prep time 12-Nd T spec. prep. 13-Nd space 14-Nd facilities 15-Nd class time	

2. What lessons have you omitted from course and why? How did you handle the topic?

Omitted Lessons	Reason	Teacher Adaptation

3. What other problems have you encountered? How handled? What do you suggest is needed?

Problem Area	Teacher Adaptation	Recommendations
Subject matter content Student subgroups Supplementary materials **Teaching Aids** Equipment (procurement etc)		

4. What lessons (IPS, CHEMS) have you used in connection with another course? Why?

IPS or CHEMS Lessons	Course in Which Used	Reason	Remarks

5. In retrospect how do you see differently the problems you first encountered in teaching this course?

6. Check other recommendations for present IPS, CHEMS teachers.

[] Conference
[] Workshop
Kind ________

[]Saturdays
[]Late p.m.

[] A few days
[] Extended Period
[] Implementation Manual

[] During Summer
[] During School Recess

[] OTHER ________

APPENDIX J
STUDENT INTERVIEW QUESTIONS

School: ______________________ Class: ____________ Period: ________

Teacher: ______________________ Grade: 7 8 9 10 11 12

S-Subgroup: ____________________

1. How is this course helping you to solve "out of school" problems?	
2. What science-related activities have you developed more interest in since taking this course?	
3. How do lab experiments help you to get more from the class, understand meaning of science terms?	
4. How do PRE LAB discussions help you?	
5. How do POST LAB discussions help you?	
6. Why are you collecting and recording lab data? What is most important about collecting data?	
7. How does graphing the data, or tabulating it help you to understand the experiments?	
8. What do you like BEST about this class	
9. What do you like LEAST about this class?	
10. How does this class differ from other science classes you have had?	
11. How is this class helping you with other classes that you are taking?	
12. What school preparation has helped you especially with this class?	
13. What additional school preparation do you wish you had taken?	
14. How have your attitudes about science and scientists changed since taking this course?	
15. Would you like to be a scientist? Why? Why not?	